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p. 660.)

THE CLOSER UNION REPORT.

THE Report* of the Commission appointed last year to consider the possibilities of closer union between Trinidad, the Windward and the Leeward Islands has recently been presented to the Secretary of State for the Colonies. The Commission, in view of the great diversity of conditions has not found it possible to propose any kind of closer union between all the islands mentioned, but has recommended that the Windward and Leeward Islands should be united into one Colony under a Governor with headquarters at St. Lucia.

The Commission in their Report deals at some length with the unification of the various services and in this connection has paid particular attention to the possibility of coordinating the agricultural services. They state that "in these services, more than in any other, a strong hand is needed" and that "a definite policy is required, which must be persevered with in spite of unenlightened and short sighted opposition". The policy to be adopted must, however, essentially be on sound scientific lines and directed by expert advice. It was found that agricultural progress varied greatly in the different islands and that in some cases advance had been retarded by the adoption of wrong methods. It was noticed, furthermore, that there was considerable overlapping and want of coordination in agricultural administration, which led to unnecessary expense and waste of energy. The possibility of devising a coordinated plan for agriculture common to all the islands thus suggested itself and was investigated. As a result, a tentative scheme, based on existing machinery, has been submitted. This scheme contemplates the formation of a reorganised Department of Agriculture for the Windward and Leeward Islands whose general policy is to be controlled by a Committee consisting of (*a*) the Principal of the Imperial College of Tropical Agriculture, (*b*) the Director of Agriculture, Trinidad and (*c*) the Commissioner, College Advisory Department of Agriculture. The personnel of the New Department is to consist, on the one hand, of the Commissioner as Executive Head, the Assistant to the Commissioner and the Biologist, and, on the other, of the local island Superintendent of Agriculture and Junior Staff officers. The former three officers would form

* Report of the Closer Union Commission (Leeward Islands, Windward Islands, Trinidad and Tobago), April, 1933.

the *Advisory Staff* and the remaining officers the *Local (Island) Staff*. It is suggested moreover, that The Trinidad Department of Agriculture, should relinquish the direction of the Grenada Department which it has hitherto supervised. In substitution, however, the Trinidad Department, is " to exercise, in association with the Committee and the Advisory Staff, a certain measure of responsibility for assistance in administration and animal husbandry matters, as well as in any special projects that might arise ". " The honorarium to the present holder of the office of Director, now paid by Grenada, would continue, but would be shared by all the islands, and Grenada would share with the other islands the services of the Advisory Staff. Thus, the Advisory Department of the College would continue its functions in the islands exactly as at present, but would include Grenada in its orbit, general policy being controlled by the Committee."

It is claimed that this scheme would leave the relations of the new Department with the College unaltered; that all the islands in the Windward and Leeward groups would in common with other West Indian colonies retain their claim on the College for educational facilities, advice on scientific matters and special investigations; and that the Advisory staff would still be at the College and carry out its present system of periodical visits of inspection to those islands. " The Trinidad Department would, moreover, retain its independent identity. No additional burden would be thrown on it, and it would benefit by closer association with the Advisory Staff and, through its Director and the Committee, with the College itself. The Windward and Leeward Islands would benefit by association with, and assistance from, an active department of agriculture larger and more fully equipped than their own which is constantly concerned with a number of problems, including those concerned with livestock common to, and of interest to most of them ". The College, on the other hand, would retain its claims on the Windward and Leeward Islands for their annual contributions on the present basis towards its maintenance, its educational and research work and advisory services. Finally, the whole scheme is regarded " as bringing all agricultural interests in this part of the West Indies into the closest cooperation " and as " a definite step forward in the coordination of the agricultural services of Trinidad and the Northern Islands without serious dislocation of existing arrangements, and without providing justification for adverse criticism, on financial or other grounds, by the Governments or public of the islands concerned ".

The Commission, however, recognises one difficulty in the execution of the scheme and that is how the executive control of the new department is to be exercised, where its policy is directed by an independent Committee and Advisory staff, while the local officials are under different authority. Difficulties have already arisen in this respect under the present system through the ideas of local officials not coinciding with those of the Technical Advisory staff; and it was represented to the Commission that if the new scheme is to be effective, it woud be desirable that it should be on an official and not on a voluntary basis. In short, that the Commissioner should be officially recognised and his position secured. The Commission, however, has come to the conclusion that this difficulty, inherent in any attempt to constitute a coordinated department where there is no federal government, could not be overcome by any hard and fast rule or legislative enactment. The success of the scheme will thus depend on the good will and the spirit of cooperation of the authorities who will be responsible for putting it into effect.

The Commission's proposals, even if they are not accepted in their entirety, should afford a useful basis for discussion by the Governments concerned.

COFFEE CULTIVATION.

Some factors in Arabica coffee growing with especial reference to the Northern Province, Tanganyika Territory.

In this pamphlet (No. 7) issued by the Tanganyika Territory Department of Agriculture, F. R. Sanders and A. J. Wakefield discuss the problem of maintaining a balanced C/N ratio in coffee plantations under Northern Province conditions in Tanganyika, where Nitrogen is the limiting factor. The reduction of carbohydrate formation to the low Nitrogen level by such methods as shading, while preventing the prevalent overbearing and consequent biennial cropping, would result in a minimum of food elaboration and a subsequent poor crop. It is suggested that the effect of the application of nitrogenous manures is strictly correlated to the time of application. Applied at bud formation it will result in a production of vegetative buds and a reduction of crop in the following year; applied near the time of flowering it may restrict the crop in the year of application; applied after fruit setting it will encourage leafage and consequently a greater assimilation of carbohydrates; thus the application of nitrogenous manures may be so timed as to offer a means of control of biennial cropping. It is considered that with regular bearing coffee the time of application of nitrogenous manures should be at least four months before the flower buds are normally visible, but in the case of coffee showing biennial bearing a heavy dressing of nitrogen should not be given until two months later, the aim being to limit flower bud formation, and thus prevent overbearing and biennial cropping.—(*Horticultural Abstracts*, Vol. III, No. 2, Ab. 237.)

EXPERIMENTATION AND APPLIED STATISTICS FOR THE PRACTICAL AGRICULTURIST

BY

D. D. PATERSON.

I.—Introductory Note.

THE science of field experimentation is a comparatively recent one, and has therefore, not yet become stabilised. Authorities still agree to differ on many controversial questions. Every year sees the introduction of some improvement in the systems advocated, both in the direction of field practice and also in the statistical interpretation of the data. It is unfortunate from the ordinary agricultural officer's viewpoint, that, while the technique is gradually getting better, it is also becoming more complicated. So much so, that it is already being realised that Colonial Agricultural Departments carrying out an extensive research programme will ultimately require on their staff at least one expert statistician. This man should possess, not only definite mathematical qualifications, but also an intimate and up-to-date knowledge of the experimental methods adopted by the leading agricultural research stations throughout the world. His duties will be twofold. He will advise the officers concerned in regard to the selection of treatments and the arrangement of plots on the ground that will be most likely to attain the desired objectives. He will then be responsible for the statistical methods applied to the data and for the ultimate collation and interpretation of the combined results of the various experimental stations in the colony.

Hitherto, the supply of men with the necessary endowments has been peculiarly limited. As a result, most of the experimental work is being carried out by the general officers of the Colonial Agricultural Departments in addition to their other duties. They become responsible for the designing, supervision and interpretation of their own experiments. The summarising of the accumulated data from various sources usually devolves upon the Director of Agriculture or his immediate assistant, who already have more work than they can reasonably perform.

The object of this article is to give, in a form easily assimilated, a brief account of some of the more commonly adopted plot arrangements used in field experiments and to describe for each, a statistical method that will give a valid interpretation of the yield data. It does not in any way purport to be a monograph on modern experimental statistics. Past experience of a Colonial Agriculture Department and present contact with agricultural cadets intended for the Colonial Service indicate that, if properly presented such information would be welcome to many who have found modern statistical theories rather elusive and confusing, but who will require some knowledge of the basic principles for the proper execution of their official duties. It is written for such individuals by one whose own doubts and inabilities can make him realise their difficulties. The statistician or experienced experimentalist is strongly advised to read no further, as there is nothing in the succeeding pages that can in any way arouse his interest.

II. Elementary Formulae.

Statistics in general are concerned with a series of measurements, quantitative or qualitative, carried out on a number of individuals or articles of one kind. These measurements are made with some definite objective, as for example, to ascertain the height of a certain race of men, or the size of seeds of a particular crop, or the best yielding variety among half a dozen varieties of wheat. As the measurements are made within a group of similar but not identical individuals, *e.g.*, a race of men, the readings vary in size from one individual to the next. The separate readings have, therefore, been termed the Variables. The number of variables measured normally is very large and, it is impossible to grasp what the mass of figures really means until the results are stated in some more comprehensible form. This is done by calculating the Mean and the Standard Deviation.

The mean, by ordinary arithmetic, is the sum total of all the readings divided by the number of individuals or variables measured.

Example I.

NOTE.— *In this example, as in all the succeeding ones, the number of variables has been kept considerably below that advisable in statistical work, and only simple integers have been used. These examples are intended solely as an aid to the non-technical reader in following the progressive steps in the arithmetic. They are all entirely hypothetical and far from typical of the unwieldy data that the statistician has of necessity to work with in most of his analysis.*

Height of Englishmen Inches.	*Height of Frenchmen Inches.*
59	55
60	57
63	60
63	60
65	72
68	74
Sum Total 378	Sum Total 378
Mean $= \frac{378}{6} = 63''$	Mean $= \frac{378}{6} = 63''$

In the above example, the mean height of the six Englishmen and of the six Frenchmen is 63 inches. As regards average height, therefore,

these two groups are identical. The calculation of the mean has rendered it possible to make a definite and easily understood statement regarding the statistical data. While the mean height is the same in both groups, the individual variables are not identical: the highest Englishman is only 68 inches, while the highest Frenchman is 74 inches. The mean does not show what the range of the individual readings is, and this is an important factor in assessing the significance of the yield data. Statisticians have devised a method of expressing mathematically the way in which the variables are dispersed or scattered round the mean. This is done by calculating what is termed the Standard Deviation.

Example II.—Calculation of the Standard Deviation.

Length of Beans (millimetres)	Deviation from Mean. −	Deviation from Mean. +	Square of Deviations.	
10	3	−	9	
12	1	−	1	Mean =
15	−	2	4	$\frac{78}{6} = 13$
18	−	5	25	
11	2	−	4	
12	1	−	1	Standard Deviation =
78	−7	+7	44	$\sqrt{\frac{44}{5}} = 2.97$

Procedure.—In calculating the standard deviation, the first step is to estimate the mean. This is then subtracted from each variable in turn to give the deviation from the mean recorded in column II. These deviations may be positive or negative, and the sign should be shown. Each deviation is squared and entered in column III, which is then summed. The Standard Deviation is the square root of the sum of the squares of the deviations divided by the total number of variables less one. In this example, the number of variables is six, and the total of column III is 44 so that the Standard Deviation is $\sqrt{\frac{44}{6-1}} = 2.97$.

Comments.—If the calculation of the mean and deviation from the mean is accurate, then the algebraic total of column II will be zero. This forms a useful check on the arithmetic.

In working out the standard deviation, the divisor of the sum of squares of the deviations is termed the number of degrees of freedom. It represents, in any estimation, the number of variables concerned less the number of constants or means from which the deviations are estimated. In the simple example cited, there is only one mean, so that the number of degrees of freedom in this case is the number of variables minus one.

Some statisticians do not use the number of degrees of freedom in calculating the standard deviation. They maintain that the correct divisor is the actual number of variables. As it is intended in this article to adhere strictly to the analytical methods promulgated by Dr. Fisher, (3) the number of degrees of freedom has been used throughout in the succeeding examples.

Let x represent any one variable,
n ,, the total number of variables,
M ,, the Mean,
d ,, the deviation of any variable from the Mean, *i.e.*, $x - M$,
σ ,, the Standard Deviation,
Σ ,, the sum of,

Then, $M = \frac{\Sigma x}{n}$

$$\sigma = \sqrt{\frac{\Sigma d^2}{n-1}}$$

III.—Easy Methods of Computing the Standard Deviation.

Where the number of variables is limited, and the measurements are recorded in integers containing only one or two digits, the direct method of working out the standard deviation as just described does not entail an excessive amount of arithmetical calculation. In general, however, in statistical analysis the number of readings taken is large, the mean is rarely a whole number, and the individual measurements often contain three or more digits. Under such circumstances, the routine arithmetic can be greatly lessened by adopting a different method of estimating the mean and the standard deviation. It is proposed to describe two of these alternative methods, and indicate the particular conditions which would make the choice of any one of distinct benefit. It should be clearly understood that, while the arithmetical methods are different, the ultimate results remain unaltered. Such methods do not supply merely approximate estimations of the mean and standard deviation, but give the true values of each. In fact, when the mean is not a whole number, these alternative systems are more accurate as they tend to eliminate the fractional mistakes that would otherwise occur in working out the deviations from the mean. In order to illustrate the various steps in the arithmetic, the data from Example II for the length of beans have been utilised.

Example III.—" Variable-Squared " method of calculating the Standard Deviation.

I Length of Beans (mm.)	II Square of Variables.	
		Mean $= \frac{78}{6} = 13$ mm.
10	100	Standard Deviation.
12	144	$= \sqrt{\frac{1058 - \frac{78^2}{6}}{5}} = \frac{\sqrt{44}}{\sqrt{5}}$
15	225	
18	324	$= 2.97.$
11	121	
12	144	
Total 78	1,058	

Procedure.—Each variable is squared as shown in column II, and the sum total of these squares entered. By subtracting a constant from this total the true value of the sum of the squares of deviations can be estimated. This constant is the square of the total of the variables divided by the number of variables, *i.e.*, in the above example $\frac{78^2}{6} = 1014$. For ease of description in the succeeding pages this constant is termed the Correction Factor. In brief,

$$\sigma = \sqrt{\frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1}}$$

This method of computation is most advantageous where the individual variables do not contain more than three digits, and the mean is a decimal fraction.

Example IV.—Assumed Mean Method of Computing the Standard Deviation.

I Length of Beans (mm.)	II Deviation from Assumed Mean of 12. −	II +	III Square of Deviations.
10	2	–	4
12	–	0	0
15	–	3	9
18	–	6	36
11	1	–	1
12	–	0	0
Totals 78	−3	+9	50
	+6		

Mean $= \frac{78}{6} = 13$ mm. Standard Deviation $= \sqrt{\frac{50 - \frac{6^2}{6}}{5}}$

$$= \sqrt{\frac{44}{5}} = 2.97.$$

Procedure.—In this case, instead of using the true mean in working out the deviations, an approximate mean is selected from a rapid survey of the figures given in column II. From this assumed-mean, the deviations and the deviations squared are calculated and summed. Once again by subtracting a constant or correction factor from the total of column III, the true value of the sum of the squares of deviations can be obtained. The correction factor in this instance is the square of the total of the deviations divided by the number of variables, *i.e.*, $\frac{6^2}{6}$ or 6.

If d_I represents the deviation of any variable from the Assumed Mean,

$$\text{Then } \sigma = \sqrt{\frac{\Sigma d_I^2 - \frac{(\Sigma d_I)^2}{n}}{n-1}}$$

In this system, the mean can be worked out by an alternative method which provides a useful check on the accuracy of the arithmetic. The true mean is equal to the assumed mean+the algebraic sum of the total of the deviations divided by n. In other words, $\frac{\Sigma d_I}{n}$, taking into account the sign + or − of this total added to the assumed mean gives the value of the true mean. In the above example $\frac{\Sigma d_I}{n}$ is $+\frac{6}{6}$ or + 1, so that the true mean is 12 + 1=13, as orignially calculated.

The correction factor in both the assumed mean and the variable-squared methods is virtually the same constant. In the former system, it is the deviations from the assumed mean that are squared so that the correction factor is based on the total of these deviations ; in the latter system it is the variables themselves that are squared, or, in other words, the deviations from an assumed mean of zero, and the correction factor is calculated from the sum of the variables.

This assumed mean method is particularly useful where the true mean is not a whole number, and the individual variables contain more than three digits. Under such circumstances the variable-squared method produces unwieldy numbers, and direct calculation introduces undesirable fractions in estimating the deviations.

IV.—The Standard Error.

In a given sample of variables, the mean is the measure of type and the standard deviation is the measure of the dispersion of these variables round the mean. In experimental work as a whole, the mean is calculated from a limited number of individuals selected at random from a whole population, *e.g.*, length measurements of 100 beans from the total harvest of a large field. If another similar random sample is taken and measured, it will be found that the mean of the second sample will almost certainly be slightly different from that of the first. A third mean from a third sample will again differ a little from the other two, and so on. Now the mean is the measure of type from which the ultimate conclusions will be deduced, and it is essential to know how far any single mean calculated from a small random sample can be relied upon as the true measure of type of the whole population. The next step in statistical work is, therefore, to calculate the Standard Error, which is the term normally applied to the standard deviation of the mean, to distinguish it from the standard deviation

of any variable, as already calculated. The standard error expresses mathematically the range of fluctuation that may be expected in the means of a series of similar random samples taken from a particular population. Its arithmetical value is obtained by dividing the standard deviation of any variable by the square root of the number of variables in the sample, or more briefly,

$$\text{S.E.} = \frac{\sigma}{\sqrt{n}}$$

In Example II, the standard deviation is 2.97 and the number of variables is 6, so that the standard error is $\frac{2.97}{\sqrt{6}} = 1.21$.

In some publications, particularly in the older ones, describing the results of field experiments, the mean is expressed as so many units ± the standard error. Thus, in Example II, the results might be summarised by stating that the

$$\text{Mean} = 13 \pm 1.21 \text{ mm.}$$

Another system, more frequently adopted today, is to record the standard error as a percentage of the mean. In this form, it is generally termed the coefficient of variability. This coefficient has the advantage of showing at a glance the relationship between the mean and its standard error, irrespective of the units in which the variables have been measured. In Example II, the

$$\text{Coefficient of variability} = \frac{1.21}{13} \times 100 = 9.3\%$$

V.—Significance.

Agricultural experiments are generally designed to ascertain whether one particular treatment, *e.g.*, variety, method of cultivation, manurial dressing, is more profitable than another for any given crop. The procedure normally adopted is to divide the experimental area into so many similar plots, and put a given number of plots under each of the treatments to be compared. At harvest, the yield of each plot is recorded and the mean yield of all plots of any series, *i.e.*, of one particular treatment, is calculated. The means of the different series are then compared to see which is the best treatment. The mean is estimated from a relatively small number of plots and is, consequently, only an approximate measure of type, *i.e.*, in this case, of the effects of any one treatment. It is now necessary to find out whether the difference (D) between the means of the various series is due merely to errors in random sampling or is the direct result of the particular treatment applied. The standard errors of any pair of means are used to calculate the standard error of the difference between the means. The standard error of this difference is the square root of the sum of the squares of the standard errors of the two means.

Let E_1 represent the S.E. of the first Mean.
" E_2 " " second Mean.
" E_D " " difference between the Means,

Then $E_D = \sqrt{E_1^2 + E_2^2}$

Or, expressing the same formula in terms of the standard deviations

$$E_D = \sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

where σ_1, σ_2, and n_1, n_2 are the respective standard deviations and number of variables in the two samples.

In some cases E_1 and E_2 are identical, and then the formula simplifies to

$$E_D = \sqrt{2 \times E_1^2}$$

or $E_D = \sqrt{2} \times$ the Standard Error of either Mean

Mathematicians have worked out Tables which show for any particular size of sample what given value of $\frac{D}{E_D}$ is necessary to make it reasonably certain that such a difference between the means is the result of the particular treatments and not of the fluctuations in small random samples. Chances exceeding 20 : 1, *i.e.*, a probability of .05 are normally taken as the measure of reasonable certainty. As a general rule, where $\frac{D}{E_D}$ is greater than 2, the chances that the particular treatment is the direct cause of this difference are more than 20 : 1. In other words, any difference between means greater than $2 \times E_D$ can be assumed to be due to treatment or, as it is generally termed, to be significant. A difference less than $2 \times E_D$ is non significant and is ignored as being possibly due to errors of random sampling.

For more exacting work, or when using very small samples, $2 \times E_D$ is not a sufficiently accurate measure of significance. It is better to refer to Fisher's (3) Table of t* for a probability of .05 and read from there the value of $\frac{D}{E_D}$ necessary to give

* This Table of t will be found as an Appendix to "Statistical Methods for Research Workers."

a certainty of more than 20 : 1. This table shows the value of $\frac{D}{E_D}$ for different sizes of sample, (n) and probabilities (P) from .9 to .01. The reading for P=.05, and a level of n on the Table equal to the number of degrees of freedom from which σ is calculated should be taken. This reading $\times E_D$ will supply the true measure of significance for the Means that are being compared.

Example V.

An experiment designed to test the relative merits of three varieties of wheat (A, B, and C) gave the following results :—

Variety.	Mean Yield in Lbs./acre.	No. of Plots of each Variety.	Standard Error.
A	1000	10	20.0
B	1100	10	14.5
C	1025	10	20.0

In this example the means are calculated from a total of ten plots only, and reference to Fisher's table of t would be preferable to using $2 \times E_D$ as the measure of significance. The value of t for n=9, (the degrees of freedom of σ) and a probability (P) of .05 is 2.262, so that any difference between means greater than 2.262 × the standard error of this difference, is a significant one.

Comparison of Means :—

Varieties A and B.

Difference between means = 100 lb.

S.E. of this difference $(E_D) = \sqrt{20^2 + 14.5^2} = 24.7$.

A difference greater than 2.262×24.7 or 55.8 will therefore, be significant. Thus, we may conclude that the difference of 100 lb. is not merely a chance one but is due to varietal characteristics.

Varieties B and C.

$E_D = \sqrt{14.5^2 + 20.0^2}$ as in the previous comparison, so that the difference of 75 lb. in favour of B is again a significant one.

Varieties A and C.

$E_D = 20 \times \sqrt{2} = 28.3$

In this case a difference greater than 2.262 x 28.3 or 64.01 is a significant one. As the difference between the means is only 25 lb., this comparison gives a non significant result.

In conclusion, therefore, as a result of this experiment, it can be stated that B is a better variety than either A or C, but that there is no difference between the yielding abilities of the A and C varieties.

VI.—The Fundamental Principles of Field Experimentation.

The difficulty of obtaining any conclusive result from agricultural experiments is too well known to need elaboration. The following are largely responsible for the complexity of the problem :—

(*i*) The number of interacting factors that must be taken into consideration.

(*ii*) The very marked effect which soil fertility differences between plots exercise on the yield data.

(*iii*) The equally influential effect of the particular season on the different treatments under comparison.

While the research worker in agriculture cannot eliminate the effect of uncontrollable environmental factors, he can considerably reduce their influence on his results by a suitable choice of treatment and layout, while by the use of applied statistics, he can be certain of interpreting the yield data correctly. In the present article, a resumé of the methods he employs to achieve this end will not be out of place.

The Site.—Since experiments are largely planned from the practical utility viewpoint, the area of land selected for the experiment should conform to the general soil and environmental conditions under which the crop is to be grown commercially. Crops grown on unsuitable soils or in an abnormal environment will give results which mislead rather than benefit the practical farmer. It is of the first importance to select the most uniform piece of ground available in order to minimise the effects of soil fertility differences between plots. A good estimate of the uniformity can be obtained from inspection of the previous crop. Soil pits are also helpful in determining whether the soil is homogeneous or not.

Replications.—A single large plot of any one treatment, even if several acres in extent, cannot give yield data of any value for comparative purposes. The experimental area should be divided up into a number of similar plots, and so many plots allocated to each treatment. The greater the number of replications of any one series, the greater are the chances of obtaining an accurate result. There should be sufficient replications to ensure a fair measure of the mean and the standard deviation. It is never wise to reduce the number of replications of any one series below four : six to ten replications are much more likely to produce conclusive results.

Size and Shape of Plot.—No particular size or shape of plot can be described as best under all circumstances. For a given number of replications, the larger the plot up to 1/10th of an acre, the more accurate are the results likely to be. There is rarely any advantage with ordinary field crops in using plots larger than 1/10th of an acre in extent. On the other hand, when the available funds or the total experimental

area are limited, greater accuracy will accrue from a large number of small plots than from a few large plots. A commonly adopted size is 1/40th of an acre, but plots as small as 1/500th of an acre, highly replicated, have been used with success.

The shape of the plot may vary from square or rectangular to a very narrow lengthy strip. The dimensions should be such as to give a correct field layout, and, at the same time, utilise most effectively the experimental site chosen.

Where border effects are likely to be excessive, the square type of plot has a lot to recommend it. On the other hand, it has been shown that under certain conditions, very long narrow plots, perhaps 4 feet to 6 feet wide and 100 feet to 200 feet long, can be beneficial in eliminating the effects of soil fertility variations.

Needless to say, in experiments where edge effect is likely to influence the yield data considerably, a border of sufficient width must be added to each plot to eliminate such effects from the yield records. The effective plot unit will then be the area within this border.

Cultural Treatment.—It is the firm opinion of the writer that all reasonable cultural precautions should be taken to ensure an even regular stand in all plots. This system is open to the criticism that such special treatment does not conform to field standards. On the other hand, yield comparisons between treatments are obviously unfair if the number of plants per plot in one series is greatly different from that in the others. With certain series, additional precautions, such as heavy supplying, may be necessary to obtain a good regular crop. This should be carried out, but records should also be kept of the germination percentage, the number of supplies, &c., required for each series, and their practical importance taken into account in formulating the final conclusions regarding the merits of the different treatments.

Repetition.—The conclusions from any single experiment are only valid for the particular season and the particular area in which the experiment was located. Before any general recommendations can be issued, it is essential to repeat the experiment over several years and in other localities and soils in order to ascertain whether results are generally true for all environmental and seasonal conditions.

Large Scale Experiments.—There is a tendency to-day to favour large scale experiments in preference to simple ones in which only a single factor is under test. The reason is that by combining a number of different comparisons as manurial treatment, spacing, variety, &c., in a single experiment, a given section of land can be made to yield more accurate results than if two or three simple experiments had been laid down on the same area. In addition, the scope of the experiment is widened, as it is possible to form an idea of the way in which the different factors react on one another. Such interactions often suggest further interesting lines of investigation which would not be apparent from a number of simple experiments. Complex experiments require more skilled supervision in the field, very careful recording, and a thorough knowledge of statistics in order to extract a complete and correct interpretation from the data. The amount of complexity advisable will depend entirely on the staff in charge of the work. There must be adequate supervision for the field work, and someone who is competent to carry out a correct statistical analysis of the data for the particular layout that is adopted. A simple experiment efficiently executed is much to be preferred to a complex one in which the results are of doubtful accuracy.

Layout and Statistical Analysis.—These two are interdependent. A well chosen field arrangement is essential in order to reduce the effect of soil heterogeneity and permit a valid estimate of the mean and standard deviation for each individual series. Statisticians have devised layouts which conform to these two essentials. It is proposed to describe a few of these standard plot arrangements and give an appropriate method of statistical analysis in each case. It will be seen that the statistical methods differ purely in regard to detail, and not in fundamentals; the basic principles and formulae used are the same throughout, viz.: those cited in the preceding sections.

VII.—Randomised Blocks.

In this arrangement the land selected for the experiment is divided up into a number of sections or blocks of similar dimensions. The number of blocks must be equal to the number of replications it is intended to use for each series. Thus, if there are to be five plots of each treatment, there will be five blocks. Rectangular or square blocks are probably the best in order to make the block area as compact as possible. This will reduce the soil fertility differences within the block to a minimum. The relative position of the blocks to one another is more or less immaterial; where the topography of the ground makes it advisable, they may even be separated by strips of non-experimental land. Soil uniformity within any one block should be the primary consideration.

Each block should be divided into the same number of plots of a given size and shape. The number of plots in the block must be equal to the number of different treatments to be compared. If five varieties are under test, there will, therefore, be five plots in each block. A single plot of each treatment will be sown in each block. Thus, every series is represented once in every block, and to this extent, the arrangement of the plots is a controlled one. The allocation of the treatments to the particular plots within a block should be a purely random one, determined by drawing lots or by other chance method. The total number of plots in the experiment is the number of treatments multiplied by the number of replications, *i.e.*, the number of plots in a block multiplied by the number of blocks.

Example VI.—Analysis of a Simple Randomised Block Experiment made up of Four Blocks of Three Treatments.

TABLE VIa.—YIELD DATA IN LBS. PER 1/40TH ACRE PLOT.

Blocks.	Treatments			Total of Blocks.	Mean of Blocks.
	A	B	C		
I	11	3	4	18	6
II	9	4	5	18	6
III	10	2	3	15	5
IV	10	3	8	21	7
Total of Treatments	40	12	20	Grand Total=72	General Mean $= \frac{72}{12} = 6$.
Mean of Treatments	10	3	5		

An elementary and somewhat crude method of analysing the data in this Example would be to take each treatment in turn, calculate the respective standard errors and use these as previously described to determine the significance of the difference between means of treatments. Were this procedure adopted, the means and standard deviations would be based on a total of only four plots in each case. This is rather too small a number of replications to give a fair measure of the standard deviation. Fisher (3) has devised a method of statistical analysis by means of which it is possible to obtain an estimate of the standard deviation based, not on the number of plots in any one treatment, but on the total number of plots in the experiment.

If the yields for the twelve plots in the above Example represented data from a sample of 12 similar variables, the general mean could be used as follows to estimate the sum of the deviations squared (Σd^2) for the 12 plots. This Σd^2 for any particular sample is generally termed the Sum of Squares or S.S.

TABLE VIb.

Plot Yield.	General Mean.	d. -	d. +	d^2
11	6	–	5	25
3		3	–	9
4		2	–	4
9		–	3	9
4		2	–	4
5		1	–	1
10		–	4	16
2		4	–	16
3		3	–	9
10		–	4	16
3		3	–	9
8		–	2	4
		−18	+18	122

The individual plot yields are, however, considerably influenced by the particular treatment given to them or by soil fertility differences between the blocks. The range of variables is, consequently, greater than would normally be obtained from a sample of a uniform population. This S.S. of 122 is, therefore, high, and to obtain a true measure of the S.S. due to twelve similarly treated plots it is necessary to subtract that portion of the S.S. that is a direct result of difference in treatment and in soil fertility between the four blocks.

If neither treatment nor block have had any decided influence on the yield data, the means of treatments and of blocks will not vary widely from the general mean, as they will represent the means of so many similar small samples. On the other hand, if any particular treatment or block tends to favour or depress the yield of its own plots, this will be reflected in the value of the mean. Hence, by calculating the sum of the deviations squared of treatment and block means from the general mean, a fair estimate is obtained of the share of the total S.S. for which these two factors are responsible.

TABLE VIc.—TREATMENT S.S.

Treatment.	Treatment Mean.	General Mean.	d -	d +	d^2
A	10	6	–	4	16
B	3	–	3	–	9
C	5	–	1	–	1
	–	–	–	–	26

As each deviation has been estimated from a treatment mean based on four plot yields, this Σd^2 must be multiplied by 4 to give the true value of the S.S. due to treatment. Therefore, treatment S.S. $= 4 \times 26 = 104$.

TABLE VId.—BLOCK S.S.

Block.	Block Mean.	General Mean.	d -	d +	d^2
I	6	6	–	0	0
II	6	–	–	0	0
III	5	–	1	–	1
IV	7	–	–	1	1
	–	–	−1	+1	2

In this case, the block means are calculated from a total of three plots, so that S.S. due to blocks is $2 \times 3 = 6$.

That portion of the total S.S. for all the plots in the experiment that is not attributable to any measurable factor is, therefore, $122 - (104+6) = 12$. This residual S.S. is really an estimate of the experimental error due to uncontrollable fluctuations in the variables *i.e.*, in the plot yields. It has been termed the S.S. Error.

The number of degrees of freedom of any particular S.S. is the number of deviations concerned less the number of constants from which these deviations are calculated. In this Example the total S.S. has therefore, 12 — 1 or 11 degrees of freedom, the treatment S.S. has 3 — 1 or 2 degrees of freedom and the block S.S. 4 — 1 or 3 degrees of freedom. Hence, the residual or error S.S. has 11 — (2+3) or 6 degrees of freedom. The following Table gives a summary of the results of the preceding calculations. Variance is a term for the S.S. divided by the corresponding degrees of freedom, and this final Table is commonly called the "Analysis of Variance", a term which in a wider sense is used to define this whole system of statistical analysis.

TABLE VIe.—ANALYSIS OF VARIANCE.

Due to	Sum of Squares.	Degrees of Freedom.	Mean Square or Variance.
Total ..	122	11	11
Treatment ..	104	2	52
Blocks ..	6	3	2
Error ..	12	6	2

A treatment variance that is decidedly larger than the error variance indicates a dispersion of the treatment means that is in excess of that between parallel plots as measured by the error variance. Such an abnormal treatment variance proves that the yield data have shown a significant differential response to the treatment accorded. A treatment variance more than three times the error variance can be taken as an approximate measure of significance. Fisher's z test provides an accurate method of determining whether the response to treatment is significant or not and wherever possible this test should be used in estimating the significance of the data. From the Table of z*, the reading for the five per cent. point (P=.05) and n_1 and n_2 equal to the number of degrees of freedom of treatment and error variance respectively should be ascertained. Half the difference between the Natural Logarithms† for treatment and error variance should now be calculated. This latter gives a value of z based on the data of the experiments. Significance exists only when this calculated value of z is greater than the observed value of z, as read from Fisher's Table of z.

The exact meaning of the terms "calculated" and "observed" value of z, as used in this article must be clearly understood. The former refers to the value calculated from the experimental data with the aid of Tables of Natural Logarithms. The observed value is the reading taken from Fisher's Tables.

* *Vide* Appendix to "Statistical Methods for Research Workers".

† Where Tables of Natural Logarithms are not available, the value of the Natural Logarithms can be obtained by multiplying the common logarithm by 2.3026.

In the present Example, the observed value of z for the five per cent. point and $n_1=2$ (Degrees of Freedom of Treatment) and $n_2=6$ (Degrees of Freedom of Error) is .8188.

$\frac{1}{2}$ Natural Log. of the treatment variance of 52 = 1.9756.

$\frac{1}{2}$ Natural Log. of the error variance of 2 = .3465.

The difference is 1.6291. This is the calculated value of z and as it is much greater than the observed value, it proves that the particular treatment has definitely affected the respective plot yields.

Where the calculated value of z is less than the observed value, the difference between the treatment and error variances is attributable to the normal fluctuations in random sampling, and any differences between treatment means are purely chance ones, and can be ignored in summarising the results of the experiment.

In this experiment, Fisher's z test has been used to demonstrate a significant response to treatment. The experiment is designed to test the relative merits of the three treatments A, B and C. It is now necessary to compare the mean yields of the various treatments, viz.:—

A = 10 lb. per plot.
B = 3 do.
C = 5 do.

The error variance represents Σd^2 due to uncontrollable fluctuations in the plot yields, divided by the appropriate degrees of freedom. From first principles, the standard deviation of any plot is the square root of this variance. Hence, in this experiment, $\sigma = \sqrt{2}$.

The standard deviation is a measure of the dispersion that may be expected in the experiment between parallel or similar plots. The means of treatments are calculated from the yields of four similarly treated plots. The standard error of any such mean is therefore $\frac{\sigma}{\sqrt{4}} = \frac{\sqrt{2}}{\sqrt{4}} = .707$.

As this standard error is common to all the treatment means, the standard error of the difference between such means $\left(E_D\right)$ is the S.E. $\times \sqrt{2}$ *i.e.* $.707 \times \sqrt{2} = 1$. The value of t for a standard deviation based on 6 degrees of freedom and a probability of .05 is 2.447. Therefore a difference between any pair of treatment means greater than the standard error of this difference $\times$ 2.447, *i.e.* in this case greater than 1×2.447, is significant.

This experiment proves, therefore, that treatment A is decidedly better than either of the other two, which are about equal in yielding ability.

VIII.—Short Methods of Computation.

The Analysis of Variance by the method just described is probably the one most easily comprehended by the beginner, but, at the same time, the

one which involves the greatest amount of arithmetical calculation. The short methods of working out the standard deviation can also be applied to the Analysis of Variance. Furthermore, it is both simpler and quicker to work throughout with the totals of treatments and blocks rather than with the means, and to use the error variance in preference to its square root (the standard deviation) in drawing up the final conclusions. The yield data from Example VI will be used to illustrate how this can be done.

Variable Squared Method.

TABLE VIF.—YIELD DATA FROM TABLE VIA.

Blocks.	Treatments. A	B	C	Total of Blocks.	Square of Variables.		Square of Treatment Totals.	Square of Block Totals.
I	11	3	4	18	121	4	1,600	324
II	9	4	5	18	81	9	144	324
III	10	2	3	15	100	16	400	225
IV	10	3	8	21	100	25	—	441
	—	—	—	—	9	9	—	—
	—	—	—	—	16	64	—	—
Total of Treatments	40	12	20	72 Grand Total	554		2,144	1,314

The correction factor is $\frac{72^2}{12} = 432.$

The total S.S. $= 554 - 432 = 122.$

The Treatment S.S. $= \frac{2144}{4} - 432 = 104.$

The Block S.S. $= \frac{1314}{3} - 432 = 6.$

In the calculation of the S.S. due to treatment and to blocks the figures squared are not single plot yields, but the total of so many plots, and it is necessary to divide the sum of such squares by the number of plots from which each was derived. The divisor in the case of treatments is, therefore, 4 and in the case of blocks it is 3. The division should, of course, be done before subtraction of the correction factor.

Assumed Mean Method.

TABLE VIG.—TABLE OF DEVIATIONS FOR YIELD DATA OF TABLE VIF FROM AN ASSUMED MEAN OF 5.

Blocks.	Treatments. A		B		C		Block Totals.		Square of Deviations.		Square of Treatment Totals.	Square of Block Totals.
	−	+	−	+	−	+	−	+				
I		6		2		1		3	36	9	400	9
									16	4		
II		4		1		0		3	25	1	64	9
									25	0		
III		5		3		2		0	4	4	0	0
									1	9		
IV		5		2		3		6				36
Treatment Totals		+20		−8		0		+12 Grand Total	134		464	54

To ensure accuracy, the treatment and block totals from this Table of deviations should be checked against the corresponding totals from the yield data. If y represents the number of plots in any particular total, then the treatment total should be equal to y × assumed mean + the total for this treatment from the Table of deviations (the sign being taken into account).

Thus the total of treatment B is 12 or $4 \times 5 - 8$ and the total of block IV is 21 or $3 \times 5 + 6$.

The correction factor $= \frac{12^2}{12} = 12.$

The total S.S. $= 134 - 12 = 122.$

The treatment S.S. $= \frac{464}{4} - 12 = 104.$

The block S.S. $= \frac{54}{3} - 12 = 6.$

The only difference between this method and the previous one is that a table of deviations from an assumed mean of five has been first of all computed, and the correction factor and the squares are based on this table and not on the actual yield data.

In both methods the individual sum of squares is exactly the same as that originally calculated. The arithmetic involved is considerably less,

even in this simple example; where actual yield data are being used, the advantage is proportionately greater.

In this instance, where the plot yields and totals are simple integers, the variable-squared method is the quickest. When one is working with larger units, the assumed mean method will normally be the one requiring least arithmetical calculation. It is proposed, in the succeeding examples, to select the one most suited to the yield data being analysed.

Provided the z test has demonstrated a significant response to treatment, the error variance can be used to compare treatment totals. This avoids the necessity of calculating the means and eliminates decimal fractions normally associated with means. The standard error of a total of n plots $= \sigma \times \sqrt{n} = \sqrt{\sigma^2 \times n}$ *i.e.*, in an analysis of variance, $\sqrt{\text{error variance} \times n}$. In the above example each treatment total is the sum of four plot yields, and the error variance is 2. The standard error of each treatment total is $\sqrt{2 \times 4}$ and the standard error of the difference between such treatment totals is $\sqrt{2 \times 4 \times 2}$, *i.e.*, the S.E. of each total $\times \sqrt{2}$. The value of t is, of course, unaltered, so that a difference between treatment totals greater than $\sqrt{2 \times 4 \times 2} \times 2.447 = 9.788$ is a significant one. This value of 9.788 is exactly four times the figure previously calculated for the significant difference between treatment means. As the treatment totals are four times the treatment means, the standard of significance remains unaltered.

The results should finally be presented in a form that allows easy comparison with the customary standards. To do this, treatment totals and significant differences should be converted to the common unit of measurement, say lb. per acre for a seed crop, or tons per acre for a bulky fodder crop. The easiest way of accomplishing this is to calculate the necessary constant by which each total will have to be multiplied. In this example, treatment totals represent the yield in lb. from four 1/40th acre plots, and each will have to be multiplied by ten to convert to lb. per acre.

Thus, the yields are:—A = 400 lb./acre.
B = 120 do.
C = 200 do.
and a difference between these yields greater than 97.88 is a significant one.

Comparison of Blocks.—The method of using the z test to determine whether there is any general response to treatment has been described. In a similar way, the block variance may be compared with error variance to ascertain whether there is any decided difference in fertility between blocks. Provided this z test gives a positive result, the error variance can be used to compare the totals of the individual blocks and, knowing the location of the different blocks in the field, the fertility drift can be plotted out on a map. This knowledge of the trend of the fertility might be of advantage in further experimental work in the same area.

Examination of the analysis of variance Table in Example VI shows that the block variance is exactly equal to the error variance. As already mentioned, significance will only exist if the block variance is considerably greater—say three times greater—than that between parallel plots as assessed by the error variance. It is quite unnecessary here to apply Fisher's z test, as obviously where the block and error variances are equal, this test will give a negative result. It follows that there is no very wide divergence in fertility between the individual blocks in the Example quoted.

The analysis of variance applied to a simple randomised block arrangement is summarised by the following formulæ:—

Let x = any one plot yield.
n = number of blocks, *i.e.*, the number of replications of each treatment.
p = number of treatments, *i.e.*, the number of plots in any block.
T = the grand total of all plot yields.
T_t = the total yield of the n plots of any one treatment.
T_b = the total yield of the p plots in any one block.

Then, by the Variable Squared method,

The Total S.S. $= \Sigma x^2 - \frac{T^2}{n \times p}$ having np − 1 degrees of freedom.

The Treatment S.S. $= \frac{\Sigma T_t^2}{n} - \frac{T^2}{n \times p}$ having p − 1 degrees of freedom.

The Block S.S. $= \frac{\Sigma T_b^2}{p} - \frac{T^2}{n \times p}$ having n − 1 degrees of freedom.

The Error S.S. = Total S.S. − (Treatment S.S. + Block S.S.) having (n − 1) (p − 1) Degrees of Freedom.

If the assumed mean method of working is adopted, then exactly the same formulæ can be used, provided x, T, T_t, T_b, refer to the Table of deviations from the assumed mean, and not to actual plot yields and totals, as originally recorded.

Significance between treatments exists if the difference between ½ Natural Logarithm of treatment and error variance is greater than the observed value of z for a probability of .05 (the 5 per cent. point)

Provided this z test is positive, a difference between treatment totals greater than

$t^* \times \sqrt{\text{error variance} \times n \times 2}$

is a significant one.

(*To be continued.*)

*Read from Fisher's Table of t for a Probability of .05 and Degrees of Freedom equal to that of Error Variance.

WEST INDIAN NOTES.

(Compiled by the Advisory Department, Imperial College of Tropical Agriculture.)

The Fruit and Vegetable Industry.

The quarter under review covers the bulk of the green lime season, the mango season and the beginning of the pear season. In addition, largely owing to the shortage of bananas in Jamaica following upon last year's hurricane and the blows and heavy rains this year, and partly owing to Panama disease increase, the Canadian market has been short of bananas. This has given rise to decided interest in this crop in the Leeward and Windward Islands, particularly in St. Lucia and Dominica and to a lesser extent, owing to export limitations, in Grenada and Montserrat.

Factors such as the partial repeal of prohibition in the United States thereby popularising beer, the drop in exchange which in 1932 helped prices considerably, and competition from other sources, have combined to react very unfavourably on the New York green lime market returns and firm orders and shipments have recently been reduced considerably. Total shipments from St. Lucia up to the end of August, however, approximate to those last year despite recent curtailment (2,620 barrels as compared with 2,488 barrels in 1932), but at the end of August Dominica was already 2,336 barrels behind the corresponding shipments in 1932 of 5,786 barrels.

The Canadian green lime market, principally in Montreal and Toronto, following the regular shipments last year in tomato lugs (about seven to a barrel) has extended considerably and has helped to a small extent to relieve the New York situation, as shown by the following figures.

To Canada.	1931.*	1932.	1933.
From			
Dominica	195 brls.	848 lugs	2,560 lugs (to end August)
Montserrat	60 lugs & some brls	1,753lugs	2,933 lugs (to end July)
St. Lucia	130 brls.	182 lugs	490 lugs (to end August)
St. Vincent....	—	54 lugs	613 lugs (to end August)

The prices have ranged approximately from $2.00 to $2.50 in the early season to $1.50 to $1.80 per lug in the main summer months. Since the packing, sea freight and Canadian (rail freight, commissions, &c.) charges amount to an average of around $1.20, the prices have proved remunerative to growers. The value of this market has been realised particularly by Montserrat and St. Vincent whose limes have never be established on the New York market. The Marketing Officer visited Grenada in July and supervised the packing of their first shipment to Canada. Shipments to Bermuda and the United Kingdom are maintaining past levels.

A scheme was put forward by the St. Lucia Agricultural and Commercial Society in June for a cess to be levied on green lime exports from the British West Indies for general green lime advertising. To date this scheme has met with general approval except in Dominica. It is hoped to bring this matter forward at the general British West Indies Fruit Conference to be held on 17th October in Jamaica where the Commissioner of Agriculture and the Marketing Officer will represent the Leeward and Windward Islands. This Conference will also prove a suitable opportunity to bring forward many other current matters of great importance to the trade such as reduction of freights and cold storage minimums to the United Kingdom, the need for more and better equipped cold storage accommodation to Canada, the possible quota shipments of tomatoes, &c.

To the end of August the St. Lucia mango exports except to the British West Indies showed a slight increase over 1932 figures as is illustrated by the following statistics, the 1932 totals being given in brackets, (the season virtually ends with small shipments in September): to Bermuda 4,205 crates (3,188), to Canada 463 crates (108) to British West Indies 2,275 packages (3,618). There have been no shipments to England owing to the cold storage minimums restriction. Dominica export figures were 1,339 crates (1,000). The increased shipments to Canada are mostly of Julie, with some Père Louis. The market has been spoilt somewhat by shipments of inferior fruit from other parts of the West Indies but sales and reports show decided indications that the mango is getting better known in Canada.

The pear season was rather later this year, St. Lucia only shipping five crates in June as compared with 218 in June 1932. St. Lucia shipments to the end of August were also lower, namely 1,457 crates (2,198 in 1932). Dominica shipments to end of August were 144 boxes. In view of the rather general fall in the market with the heavier August and September shipments some reduction in exports is all to the good. The Bermuda agents are demanding the green-skinned, as against the purple-skinned, seedling pears in view of the former's better keeping and firmer ripening qualities.

The banana exports have assumed relatively considerable proportions this year. St. Lucia shipped 11,699 bunches to the end of August (Canada, 10,623; British West Indies, 836; United Kingdom 240). Following the trial shipment of 240 in July to the United Kingdom a further shipment of 743 was made in early September. Dominica shipped 10,968 bunches to

* The 1931 shipments largely consisted of one combined shipment in barrels for advertising. This year a small proportion of the fruit has been shipped in barrels to meet the needs of larger consumers.

the end of August (United Kingdom, 6,586; Canada, 4,382); shipments to England have continued and several thousand bunches have also been shipped to Canada. Despite the long time in transit involved the English shipments have been proceeding satisfactorily, but the Canadian shipments have been giving trouble. When the latter shipments were small, 1,000 or under, the fruit arrived in good condition, despite the use of the still-air grid cold-storage system instead of the forced cool-air draught system usually employed. Larger shipments, however, resulted in the filling up of chambers (instead of, say, stowing two stems high) with consequent reduction of air circulation and with increased bulk to cool, and the results have not been so satisfactory. The requisition of space for bananas has also resulted in more bulk-stowage of other fruit and pears have been arriving over-ripe in Bermuda. Restriction of shipments of bananas and other fruit to avoid stowage in too much bulk is essential, pending the provision of more accomodation operated by the forced draught system.

During July and August Dominica shipped some 1,000 crates of off-bloom oranges, and a few grape fruit. These have been realising good prices, around 18/- to 20/- per case in Bermuda and $3.50 in Canada. The main crop is now starting and an export of around 10,000 crates is expected from Dominica and St. Lucia, mostly from Dominica, of which about 60 per cent. will be grapefruit.

The tomato crop figures are now to hand. Montserrat only netted 0.8 cents per lb. on Canadian shipments last season and trial shipments to the United Kingdom and United States of America gave debits of 2.8 cents and 3. 7 cents per lb. respectively. This resulted in an operating loss to the Marketing Depot of some £80. St. Vincent, with a smaller crop grown entirely for the late market, which is possible under the local heavier rainfall conditions, netted two cents per lb. In consequence, reduced exports, at any rate from Montserrat, are expected next season.

* * *

Sugar Cane Investigation Committees.

In these notes for* April reference was made to the Trinidad Sugar Cane Investigation Committee and to the work it is doing for the sugar industry of Trinidad with particular reference to the control of pests and improved cultural and manurial practices. Impressed with the need that exists for improving the standard of sugar cane agriculture in Antigua and St. Kitts and more especially for raising cane yields on the more backward estates in both Islands, Sugar Cane Investigation Committees have recently been formed which are to be financed by factory owners and leading planters who have combined to contribute in equal shares to the expenses. Full use is to be made by the interests concerned of existing machinery. Mr. P. E. Turner, Chemist to the Trinidad Sugar Cane Investigation Committee has been appointed Adviser in Sugar Cane Experiments to the Advisory Department, the Trinidad Committee having agreed to make his services available to the other Islands. The staffs of the local agricultural departments are to be strengthened where necessary to enable the detailed work to be undertaken by them. The Commissioner of Agriculture and his assistants and other scientific workers will be honorary members of the Committee.

* * *

The Sugar Industry.

The 1932-33 sugar crop has been, as far as yields are concerned, most favourable, with increased tonnages recorded everywhere, the returns being as follows:—

	Tons.	No. of Factories
Trinidad ..	120,763	9
St. Kitts ..	24,167	1
Antigua ..	23,875	3
St. Lucia ..	4,703	4

In Trinidad 42 per cent. of the whole output came from canes supplied by small growers, no fewer than 17,000 people having contributed during the year. The bulk of the canes in the other islands was supplied by large estates, cane farming as known in Trinidad not being developed to the same extent. In both Antigua and St. Kitts, however, increased quantities of peasants' canes have been purchased, a source of supply which is likely to expand in future years. It is hoped also that the St. Kitts factory will absorb more cane from Nevis in the future as special arrangements having been made for handling increased quantities.

The extent to which centralisation of factories has taken place in the various Islands may be gauged from the table above. In St. Kitts centralisation is complete, the Basseterre factory having handled the whole crop of the Island this year at the rate of a ton of sugar from 7.75 tons of cane. In Antigua one factory produced 88 per cent. of the total output. In Trinidad the Usine Ste. Madeleine, produced 38 per cent. of the island crop. In St. Lucia further centralisation is impossible owing to the configuration of the country.

The increased yields of cane have been due mainly to favourable weather conditions—ample rainfall, well distributed. Improved varieties and better cultural methods have also contributed their share. One estate in St. Kitts, reaping from 300 acres, had an average yield per acre of 38 tons of cane or just under five tons of sugar, six others produced over 30 tons of cane per acre. The average yield of all St. Kitts' estates for 1933 is given as 24.27 tons of cane equal to 3.13 tons of sugar per acre. Similar figures are not available for Antigua and St. Lucia but it is known that certain estates have high yields to their credit.

* *Tropical Agriculture*, Vol. X, No. 4 page 107.

Sea Island Cotton.

The Conference of Sea Island cotton growers which it was proposed should be held in Trinidad in September has now been postponed to the first week in November when Mr. F. A. Stockdale, Agricultural Adviser to the Secretary of State will be in the West Indies and hopes to be able to attend. As there will be delegates from all the local associations, a representative meeting is anticipated. The Agenda of the Conference has been circulated, the chief item being the formation of the West Indian Cotton Association.

There has been considerable movement in the West Indian Cotton situation during the last few months, large stocks having changed hands though there is no evidence that these stocks have gone into consumption. A policy of restricted output is necessary for at least another year if surplus stocks are to be reduced and a policy of controlled output will be necessary for some years if the existing state of affairs is not to be allowed to recur.

The Montserrat Cotton Crop for 1933 is now being reaped and good yields are recorded. The Pink bollworm is reported to be very scarce. The ginning outturn is higher than usual being not less than 30 per cent. and it is obvious that the control of the seed supply by legislation is having a beneficial effect in this direction.

* * *

Miscellaneous News.

Mr. A. C. Shill, Marketing Officer has been re-engaged for a further period of one year.

* * *

Mr. T. P. Jackson, Agricultural Superintendent, St. Vincent, after serving in the West Indies for 27 years retired on pension on 31st August, 1933. Mr. P. Morrison will act as Agricultural Superintendent until a successor to Mr. Jackson is appointed.

* * *

Mr. A. F. Nichols, Agricultural Assistant, St. Lucia, returned from vacation leave during July. Whilst in England Mr. Nichols visited the Imperial Bureau of Mycology, The Imperial Institute, Kew Gardens and the Research Stations at Jealotts Hill and East Malling.

* * *

Mr. Harold E. Box, Entomologist, Colonial Development Fund arrived in St. Lucia early in August from Antigua with a consignment of Lixophaga. Arrangements have been made for the artificial rearing of these flies and for their release on the four large sugar estates. Mr. Box returned to Antigua after a stay of four weeks.

* * *

The Acting Commissioner, travelling by air, paid visits to Antigua and St. Kitts on 21st June. On 13th September he again proceeded to these islands, by way of Montserrat, returning on the 30th September. Leaving Trinidad on 28th August he paid an official visit to St. Lucia returning on 5th September. He attended a meeting of the Land Board in Antigua and a meeting of the Board of Agriculture in St. Lucia.

Mr. G. A. Jones, Acting Commissioner of Agriculture and Mr. A. C. Shill, Marketing Officer will represent the Leeward amd Windward Islands at the Fruit and Vegetable Conference to be held in Jamaica in October. Mr. Jones will also represent the Imperial College of Tropical Agriculture at this Conference.

* * *

Invitations have been issued by the Principal of the Imperial College of Tropical Agriculture to hold the forthcoming Conference of cotton growers at the College. The date of the Conference has been fixed for 31st October to 6th November when Mr. F. A. Stockdale, Agricultural Adviser to the Secretary of State is expected to be in Trinidad.

* * *

Brevities.

The area planted in cotton in Antigua for 1933-34 is not expected to exceed 100 acres.

* * *

A black headed Persian Sheep was imported into St. Kitts from Trinidad during July.

* * *

An importation of pure bred pigs was made by a planter in Dominica through the Advisory Department of the College during the month of August.

* * *

A considerable trade in grafted mangoes is developing between St. Lucia and Canada. Grafted mangoes are wrapped in paper on which is printed instructions as to how the fruit should be eaten.

* * *

Up to the end of August over 14,960 budded limes, 3,013 budded grapefruit and 1,730 budded oranges had been distributed from the Government nurseries in Dominica. The price charged for budded grapefruit has been reduced to 2*d.* per plant.

* * *

There is a shortage of rain recorded for Antigua during the last few weeks which somewhat is retarding the growth of the cane. A similar shortage is recorded for St. Kitts although in July heavy rains fell at the time of the storm which passed North of the Island on the 25th of that month.

* * *

A proposal to advertise green or fresh limes in the United States of America and elsewhere, emanating from the Agricultural Society of St. Lucia, is receiving the consideration of other Islands. It is hoped that this important question will be placed on the agenda of the Jamaica fruit and vegetable conference.

* * *

A course of lectures to School Teachers is being given by the Agricultural Department in Montserrat. The Assistant Agricultural Officer undertakes the Science Teaching in the Grammar School in this Island and there are several gardening pupils under instruction at the Experiment Station.

THE USE OF THE TRACTOR IN TRINIDAD FOR SUGAR-CANE CULTIVATION.

By C. R. Massy and D. D. Paterson.

Introduction.

The cane crop is one which responds almost indefinitely to really good cultural treatment. The tendency is ever towards deeper and more thorough tillage, heavier manurial dressings, and better drainage facilities. The field practice in Hawaii, Puerto Rico, and some other important cane sugar producing countries illustrates mechanised farming in its most efficient and up to date form. Chiefly because of the peculiar physical and topographical conditions under which the crop is grown here, Trinidad in the past has been unable to use, to the same extent, mechanical aids to cultivation. Within recent years, the improved efficiency and the greater choice in power operated implements have rendered them more adaptable to local conditions. In consequence, all the large sugar estates in the island now favour mechanised cultivation on an extensive scale. Various systems have been tried, including Fowler's Steam Cable Tackle and Gyrotiller, McLaren's Diesel Cable Tackle, and large tractors with suitable ploughing and cultivating equipment. Of these, tractor draught is probably the most popular to-day, from both the economic and utilitarian aspects. On Trinidad sugar cane estates only heavy high power tractors fitted with a caterpillar track are suited to the type of work to which they are put. Any tractor less than 30 h.p. or five tons in weight is non-economic, as the wear and tear is excessive and the power output is too small to allow completion of the necessary daily acreage. The Holt or Caterpillar 30 and 60 h.p. machines are deservedly popular and with proper attention have given many years of sterling service under very trying conditions.

Local Conditions.

In order to understand the system of tractor cultivation adopted in Trinidad one must have a clear conception of the general field conditions on the large sugar estates. These last can be grouped into two main classes in accordance with the soil and topographical features of the locality in which they are found. The first group consists of estates situated on the northern and central plains where the soil is a deep alluvial silt of fairly recent origin. This soil is generally lacking in organic matter and has a tendency to acidity. In addition it is difficult to drain, as the whole area is flat; a large proportion of it might be described as reclaimed swamp. In such lands the heavy tropical rains *in situ* combined with the liability to excessive flooding from the surrounding higher lands makes an efficient drainage system imperative. To effect this, the cultivated land is normally divided into small square or rectangular fields of from 10 to 20 acres each. These fields are enclosed on two, three or four sides—depending on the drainage requirements—with large main drains some five to six feet in width and depth. On the outside of these drains lie the field-roads or traces which are unmetalled but are used by carts going to and from the field with farmyard manure, artificial fertilisers, canes, &c. In dry weather they form quite effective means of communication, but after severe rains, if the traffic is heavy, as during crop harvest, they become quite impassable to any laden vehicle with animal draught. The cane traces serve another purpose as they supply during the wet season of the year most of the bulk fodder required by the estate oxen; this roughage comes from the natural growth of mixed herbage found on the traces and used as a soilage crop for feeding to the stock.

Each cane field is sub-divided by smaller drains into narrow rectangular beds 200 to 600 feet in length and 18 to 22 feet wide; these drains carry off the surface water and discharge into the mains. At the top end such laterals are about two feet in depth and width, but normally, in order to provide the necessary fall, they are considerably deeper at the outlet. The lie of the beds in relation to the main drains depends entirely on the slope of the land; they are laid out in the direction that will utilise most effectively the natural drainage of the area. In order to procure the necessary surface flow of water from the centre of the bed to the lateral drains on either side, the beds are all heavily cambered or 'round-ridged'; the crown may be anything from 6 to 18 inches higher than the shoulders of the adjoining drains (*vide* Figs. 1 and 2).

The second group of cane lands is found in the south of the island where the country is of an undulating nature and is broken up into a series of hills, valleys and flats. There are numerous ravines and rivulets which make effective drainage a relatively straightforward proposition but introduce a second problem in the form of susceptibility to serious soil erosion. The soil types in this locality vary from black fertile marls to heavy red or brown clays, often acidic in reaction, deficient in humus and in need of flocculation. Here again effective drainage is an essential of good cane cultivation, and the land is divided into long narrow beds by surface drains similar to those already described. In order to obviate unnecessary erosion, these laterals follow approximately the contours of the area and discharge at their extremities into the numerous small ravines, which in turn connect with the large natural drainage channels of the area. With such a contour system of drainage, the field lay-out is more irregular than is found in the central plains, but the division of the land by fairly deep drains into relatively small field units still holds good.

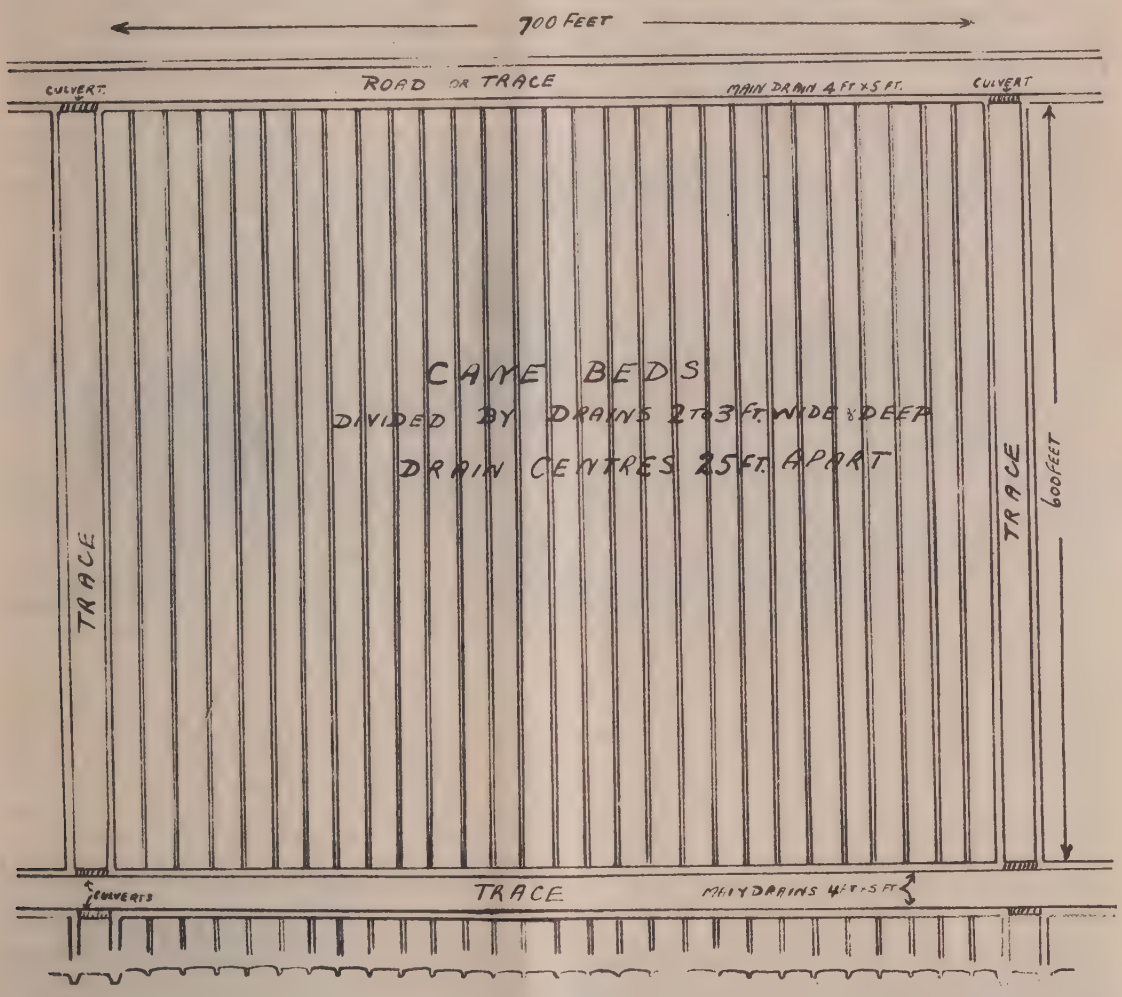


FIGURE 1.

TYPICAL TEN ACRE FIELD ILLUSTRATING METHOD OF DRAINING & ARRANGEMENT OF CANE BEDS.

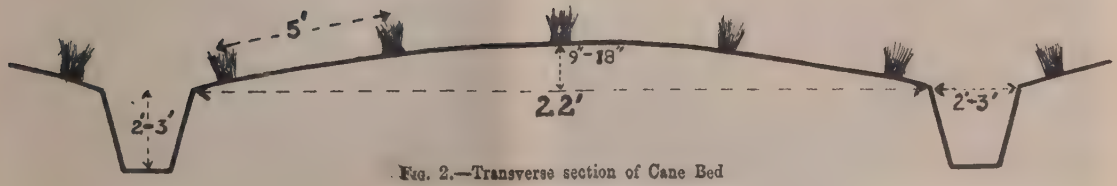


FIG. 2.—Transverse section of Cane Bed

Tractor Cultivation.

(*a*) *Virgin Lands.*—While cultivation with cable tackle and steam or diesel engines has met with a considerable measure of success in the central plains, it is of little practical utility in the undulating cane fields of the south. Cable drawn implements are used there to a limited extent on some of the flatter valley fields but the tractor is obviously the implement really suited to the locality. It is, of course, equally adaptable to the alluvial plains, but there it has to compete on level terms with the other forms of mechanised cultivation. For example, in 1932 a demonstration on a central sugar estate with Fowler's Gyrotiller indicated that this implement has undoubted possibilities for cane cultivation in that locality; the only apparent drawback is the original heavy capital outlay for a single machine that has still to prove its economic worth under Trinidadian conditions. However, the object of the present article is not to compare tractor cultivation with other forms of mechanised ploughing, but to try and describe the specialised technique that has developed here as a result of the extensive use of tractor drawn implements for soil cultivation on the sugar estates.

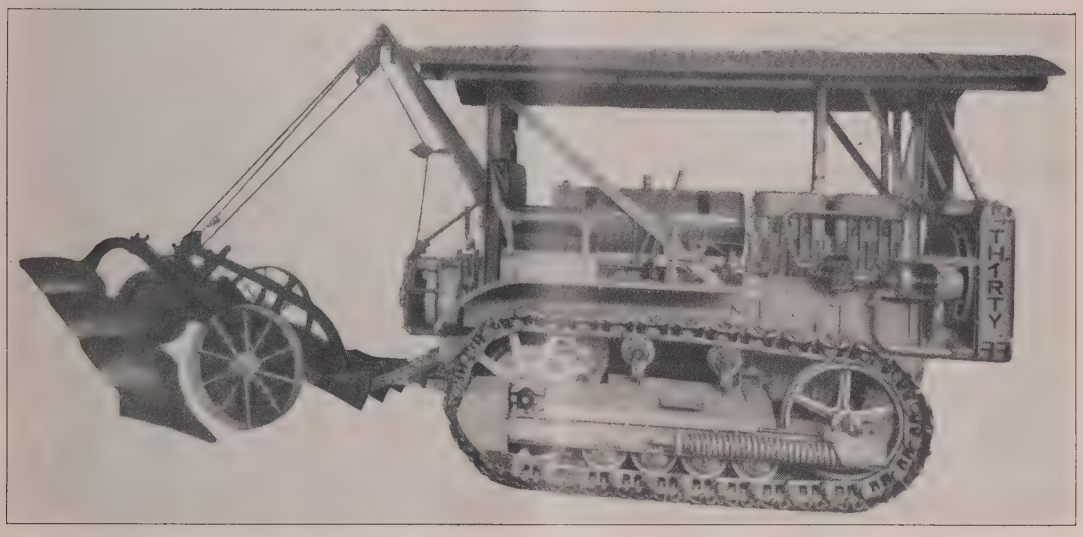
Although it may seem paradoxical, it is a definite fact that in Trinidad the breaking in and cultivation of new areas with the tractor is generally a more straightforward and less skilled operation than that of working with the same implement in old cane land. Therefore, it is proposed to describe first of all the normal way in which a tractor might be used to prepare such virgin land for a plant cane crop. For this purpose the disc plough is *facile princeps*. It is decidedly more efficient than the mouldboard type for ploughing in hard-baked clay soil covered with a thick growth of bush and coarse grass, and impregnated with roots of varying thickness. The only drawback that might be mentioned is the fact that, from its design, it is not adapted for ploughing against the slope, and in consequence there is a tendency to keep on turning the furrow slice down hill, which ultimately produces undesirable denudation of the higher sections. According to the size of the tractor, a two to four furrow gang plough is used and a furrow slice 10 to 12 inches in depth, turned over. When ploughing is completed the field is left to weather until the hard lumps of baked soil have attained a semi-friable condition. As originally turned up by the plough, especially in the clay soils of the south, they are quite impervious to any of the common types of tillage implement. After weathering, the land is quite often subsoiled, or, as it is termed in Trinidad, 'chiselled'. Though this operation is not always deemed necessary, some authorities consider it to be quite as important as good ploughing for the production of a heavy crop and even suggest that, when the soil is in suitable condition, ploughing may be omitted on areas that are to be 'chiselled'. Chiselling is particularly effective, on land free of bush, during the dry season when the ground is hard and brittle and breaks up easily under the action of the tines. When this subsoiling is carried out in unploughed land the implement is very strongly constructed and carries only a few heavy tines, about one inch thick by four to six inches in width, set edgeways on the frame and staggered as regards their relative arrangement to one another. Different styles and shapes of point are used but they are all easily detached and replaced when worn out. They are normally set to work a few inches deeper than the average tractor plough operating in the same area. A single tine can till effectively a strip of soil only nine to ten inches wide, and as the number of tines that the tractor will pull is limited, it is usually necessary to go over the same area twice to ensure that all the soil is thoroughly cultivated. The tines should be spaced out on the frame so as to avoid having to drive the tracks of the tractor on the second journey over the lines already cultivated. Thus, presuming a 42-inch tractor tread and three tines, one tine will be attached centrally on the frame and the others, 21 inches on either side. On the second time round the tractor is driven between the lines left by the first cultivation, and an effective working distance between tines of 10½ inches will be obtained.

Where the subsoiler follows the plough a heavy multiple chisel cultivator is used with the tines again staggered and set some ten to twelve inches apart measured across the chassis. They should be adjusted to work two to three inches deeper than the plough, so that any hard pan formed by the plough sole is broken. At the same time the tracks of the tractor and the movement of the tine bodies or knives through the soil help in the pulverisation of the upper layers.

Before the next cultural operation can be started the drain lines have to be plotted on the ground. A tractor drawn grader is then introduced to 'round-ridge' or form the cambered cane beds. This implement is similar to a large road grader with an eight to ten foot blade. With the grader, the soil is worked up towards the centre of each bed, and in consequence a shallow V drain is formed between the beds. In addition, the wheels and blade of the grader and the motion of the tractor produce a fair surface tilth. When this operation is completed the field is in a condition which, thanks to the shallow drains, can cope with any normal rainfall and is not liable to become waterlogged. The V drains may ultimately be deepened with a tractor drawn ditching plough, and the finishing touches added by manual labour as opportunity occurs.

In this state the beds can safely be left to weather for a further period pending the final cultivation prior to planting. This last cultural operation consists of making the furrows into which the cane sets are ultimately planted. The furrows may be made across the bed or along it. In the former case, manual labour has to be used and implemental after-cultivation is obviated. It is a method

THE USE OF THE TRACTOR IN TRINIDAD FOR SUGAR-CANE CULTIVATION.



The Hydraulic Hoist as fitted to a Caterpillar 'Thirty.'

The ploughing unit in operation.

A well ploughed field in a condition to utilise, to the fullest advantage, the effects of 'weathering'.

THE USE OF THE TRACTOR IN TRINIDAD FOR SUGAR-CANE CULTIVATION.

A three-furrow disc plough at work in heavy clay soil covered with a dense growth of grass and bush.

Easy work for the disc plough.

THE USE OF THE TRACTOR IN TRINIDAD FOR SUGAR-CANE CULTIVATION.

One type of subsoiler or "Chisel" as used on unploughed land.

The "Chisel" in action.

THE USE OF THE TRACTOR IN TRINIDAD FOR SUGAR-CANE CULTIVATION.

Intercultivation of the young ratoons.

Typical ploughing scene on the undulating cane fields of Southern Trinidad.

still followed in some of the wetter localities where rapid drainage is of primary importance. It may even be advantageous in providing work for the permanent estate labour between the harvesting and planting seasons. Where tractor furrowing is practised, the furrows must be made along the bed, and the operation becomes comparatively simple. Normally, two furrowing bodies are attached to a single tractor, the resultant furrows being five feet apart. In this case, the cane will be planted in rows along the bed, and inter-cultivation in the young crop with tractor or animal drawn implements becomes feasible.

(*b*) *Old Cane Land.*—The *modus operandi* just described for tractor cultivation in virgin lands presents no unusual features. The most difficult job is probably the staking out of the drainage channels so as to obtain a really efficient system at minimum cost. When an attempt is made to introduce tractor tillage into old cane lands, difficulties at once crop up. The tractor and plough is a large unit to manoeuvre in cane beds only about 20 feet in width. These beds are separated by relatively wide and deep drainage ditches which are in many cases impassable to the tractor and plough; even when the tractor itself can cross the plough tends to jam. The beds are all carefully cambered and the drains have been made and kept clear at considerable cost. Unless great care is taken the reploughing will spoil the camber and fill up the surface drains. Cane estates have managed to work out a technique for tractor tillage which, in the hands of a skilled driver, effectively solves these problems.

A special draw-bar and hinge plate are fitted to the tractor which is provided with a power driven hoist or hydraulic lifting apparatus. The plough is attached to the hinge-plate by a semi-floating hitch, which allows a certain amount of lateral play between tractor and plough. In consequence the tractor can be steered about 20° to the left or right without straining or affecting the ploughing unit behind. The hydraulic hoist makes it possible for the operator to lift the plough up in the air to about 60° above the horizontal (*see* plate, page v). When this is done the tractor is virtually a free unit as regards manoeuvring in a confined space. As the Caterpillar type of tractor can turn practically on its own axis, this special equipment makes cultivation within the narrow cane bed a perfectly feasible proposition. The tractor finishes work in one bed before it need cross to the next.

The plough used is always of the mouldboard type as the action of the land side of the plough sole against the furrow wall prevents the implement from side slipping into the drains. With the disc plough this side slip is much more liable and, in addition, as the furrow slice is always turned against the slope of the camber, the disc plough will not do good work. The plough should be chosen and adjusted so that the strip ploughed in each trip of the tractor is a suitable multiple of the width of the bed. This will avoid any waste of time that would otherwise occur by having to use only part of the plough on the final journey to turn over a relatively narrow strip of unploughed land. In working the edges, the outside track of the tractor is driven along the shoulder of the drain and the rear or outermost share is adjusted to follow directly behind this track. This rear share therefore operates along the drain shoulder, and prevents the formation of an undesirable furrow wall which would inhibit proper surface drainage into the adjoining ditches. It is essential, also, with this type of work that the land or depth regulating wheel of the plough should travel along a line inside the path of the rear share, otherwise, in the final cuts in any bed, it will project into the drains and satisfactory ploughing will not be possible.

The first furrow is opened in the centre of the bed and on the return journey the share of the first mouldboard is set to plough under this furrow slice so that it is turned back on itself. If this is not done a strip of unploughed land covered by the first soil turned over would be left. The tractor continues working round and round the bed, and, in each successive journey, the furrow slices are turned in towards the centre of the bed, *i.e.*, against the slope of the camber. In this way the round ridging is not only maintained but even accentuated and good drainage is ensured, without having to re-camber the beds and remake the ditches.

If the hydraulic hoist is not fitted to the tractor, the general procedure is much the same but it is not possible to turn the tractor and plough within the 22-foot bed. After the first trip down the bed, the plough is lifted clear of the soil by the conventional self lift device and the tractor is driven across the ditch to the adjoining bed or perhaps to the one beyond that. In this new section a central furrow is again opened but in the opposite half of that ploughed in the original bed. At the end the tractor crosses back to the first strip and so on, until two half beds have been completely ploughed, the left half in one case and the right in the second. By reversing the direction of motion of the tractor the remaining halves of the beds can be ploughed in a similar manner, working from the centre of the bed outwards to the drains. In actual practice it is customary to start at one side of any given field and work gradually across it ploughing only half sections of each bed. The same direction of travel is therefore maintained till the opposite side of the field has been reached. The operator will then reverse his direction of motion from clockwise to anticlockwise or *vice versa*, and work progressively backwards across the field, ploughing the remaining half sections of each pair of beds in turn, till he reaches the side he started from, when the whole field will have been completed. As previously mentioned, this crossing over from one bed to the next will almost certainly entail the filling up by hand of portions of the intervening drains in order to allow the tractor and plough

to cross. After cultivation is completed the drains at the crossing points will have to be reopened. Where the hoist is fitted the only drain filling that has to be done is at the bed head to allow the tractor to cross the main drain between the cane trace and the cultivated land. A larger acreage will be completed in the day, as the time spent in turning, when the tractor spins round on its own axis, is negligible. Furthermore, the use of the hoist makes it possible to plough effectively right up to the end of each bed, so that no unploughed or badly ploughed headlands are left. Such headlands are unavoidable on the system in which the tractor has to be continually crossing and recrossing from one bed to the next.

The hydraulic hoist is equally efficient when used in conjunction with the subsoiler, or inter-row cultivator or the double mouldboard furrowing plough. When worked with any of these implements the advantages, already described in connection with the plough, all hold good.

It happens occasionally that for some reason or other the original drainage system has to be changed. This entails the filling up of all the old drains as a preliminary to the establishment of the new. Once again the tractor has proved itself to be both an efficient and economical working unit for putting the land into a suitable condition for replotting. The ploughing procedure is the exact reverse of the one already described. Ploughing commences along the edge of the bed-drains, and, with a three or four furrow plough, it is possible to adjust it so that the first two furrow slices fall into the drain. Assuming that the hoisting device is fitted, the tractor now returns along the other side of the bed and turns another two furrow slices into the drain. Thus, as it works round, the furrow slices are turned down the slope of the camber and the fields are partially levelled at the same time as the lateral drains are filled up. Where no hoist is used, the tractor cannot return along the same bed but once again it has to cross over to an adjoining one on the return journey. Half sections of alternate beds are therefore ploughed progressively, and when the far side of the field is reached a reversal of the direction of travel enables the operator to plough the second half of the field and complete the filling up of the drains. As the furrow slices are always being turned down the slope, either the disc or mouldboard type of plough may be used.

After being ploughed, the land will normally be left to weather for a period and then the subsoiler may or may not be used, depending on the cultural condition of the field. The next operation is the staking out of the new drainage lines on the ground, preparatory to the employment of the grader for the roundridging of the new beds.

(c) *Inter-cultivation.*—Inter-row cultivation with tractors in the standing crop is being extensively used today. It can only be done in the young crop up to the time it is some two to three feet high, and provided that the rows of cane have been planted along the bed and not across it. It has been particularly successful in the ratoon crop and normally follows close after harvest. This method of working among the young ratoons is much more economical than the old system of hand-forking. Tractor cultivation is possibly not quite as efficient as really careful hand-forking and a certain amount of unavoidable damage is done to the cane stools. The saving in time and money more than counterbalances these minor disadvantages. If the cane has not been burnt the trash has to be ranged to allow the cultivator to operate. This ranging may consist of temporarily clearing all the trash into the adjacent drains or the trash may be raked into alternate rows leaving half of the ground surface exposed. This half is then cultivated after which the trash is collected on to the cultivated rows and the tractor works the second half of the bed. Whichever system is followed, the trash is finally spread evenly over the whole bed. Both the tractor and the cultivator straddle the row of cane stools, and the tines are usually arranged in two groups of three, the groups working on opposite sides of the row. In a single journey, therefore, two inter-row spaces or a 10-foot wide strip is cultivated. A heavy orchard type of cultivator with good clearance may be used or a specially constructed implement attached direct to the tractor. The tines are set to work to about nine inches in depth. This practice of tractor inter-cultivation is one more favoured in the heavy soils in the southern cane fields than in the central plains where the canes are frequently planted across the bed and not along it.

Secondary Benefits from Mechanical Cultivation.

Apart from the face value of the various cultural operations carried out with power implements, there are some additional advantages that are of considerable importance. A good proportion of the mechanical cultivation is done during the dry season of the year when cane harvest is in full swing. All the available labour is being utilised for cutting and carting the crop and very few men can be spared for other field work. Relative to the acreage finished each day, the number of men required to operate the machine drawn implements is negligible. Furthermore, hand forking in heavy soil in the dry season is often impracticable as the soil is too firmly caked for the manual implements to have any effect. Power implements are, on the other hand, working under entirely suitable conditions, and render it possible to make full use of weathering effects for the preparation of the land for the plant cane. In some cases, crop planting is practised, so that the sets, put in during the dry season, begin to sprout as soon as the first rains come in May.

Finally the speed with which a large area can be cultivated with power machinery makes it possible to carry out most of the field operations at the optimum time of the year. This in turn ensures that the cane yield will be as good as the

particular soil and season can produce. It should be clearly understood that mechanical cultivation does not eliminate the need for manual labour on sugar cane estates. Much of the work has still to be done by hand, and the tractor or other form of mechanised cultivation is supplementary to the manual worker. In a way, it is the labourer's best ally, doing for him the arduous tasks that he cannot do himself or at a time when he is otherwise engaged and so providing work for him in the slack season when he is needed to plant, drain, fork or otherwise care for the young growing crop.

V.—Costings.

The following is an estimate of the cost of operating a typical 35 h.p. Caterpillar tractor under average conditions in Trinidad. The costs are based on 1,000 working days, or, at 145 days per year, approximately seven years effective service.

	Trinidadian Dollars (1)	
Current price of Tractor in Trinidad (2)	.... $3,850	
Annual depreciation equivalent to	550	A total of $742 per year or approximately $5.10 per working day.
Annual interest on original capital outlay at 5 per cent.	192	
Cost of Operation per 10-hour Working day.		
Interest and depreciation as above	....	$ 5.10
Fuel (petrol) 30 galls. at 11 cents per gallon (3)	....	3.30
Lubricating oil and grease	....	.90
Renewals and repairs	....	3.20
Driver and assistant	....	2.50
		$15.00

(1) The Dollar in Trinidad is based on Sterling, $4.80 being equal to the English Pound.

(2) This price is based on an Exchange Rate of $113.50 Trinidad Funds, to $100.00 U.S. Currency.

(3) A recent fall (July, 1933) of 25 per cent. in the price of petrol in Trinidad has reduced the bulk cost (cum tax) to 27 cents per gallon. As petrol used for agricultural purposes is free of tax, this is equivalent to the 11 cents per gallon quoted above.

This is equivalent to 4.3 cents per h.p. hour. With the higher horsepower tractors, and particularly with the new Caterpillar Diesels which are now available, the cost per h.p. hour is even less.

A "Thirty-five" Caterpillar tractor in good working order, fitted with suitable implements, should complete under average conditions the following acreages in a 10-hour working day.

	Acres.			*Trinidadian Dollars* (1) *per acre.*
Ploughing, 10-12" deep 3½-4½ at an average cost of $ 4.50				
Chiselling in unploughed land, 13-15" deep	4-5	do.	do.	4.00
Cultivating and sub-soiling, after ploughing, 12-14" deep	7-9	do.	do.	2.00
Grading new cane beds	4-5	do.	do.	4.00
Furrowing before planting	9-12	do.	do.	1.50
Intercultivation of ratoons, 8-10" deep	12-15	do.	do.	1.50

These estimates do not include any allowance for manual labour employed in touching up after the power implements have left the land. The amount of such hand work required will vary considerably with the particular cultural operation, the type and condition of the soil, and the skill of the tractor driver.

On the heavy clay soils and undulating lands of the southern cane districts, the acreage worked in a day may be anything from 30 to 40 per cent. less than that quoted above, and the cost per acre will be proportionably greater.

(1) The cost of $15.00 per day for operating the tractor alone has been arbitrarily increased some 10 to 15 per cent. to allow for depreciation, wear and tear, and repairs of the cultural implements. In consequence, the cost per acre for each cultural operation has only been quoted to the nearest half-dollar.

VEGETATIVE PROPAGATION OF TEA.

In an article by J. R. Tubbs (*Tea Quarterly, V.* 1932) the following method of layering in Formosa is described. The ground round the bush is ploughed up, the lower branches are bent down and sharply twisted near their origin, pegged down and buried, the upper part being left above the soil. The plants so formed are rooted and ready for removal within six months. The "China jat" type bush roots more readily than the "Assam jat".

Propagation by hardwood cuttings is successful only to the extent of about five per cent. Softwood cuttings rooted by Tunstall* in a glass propagator obtained 53 per cent. success in six months. Splitting a young seedling down the centre in such a way that one cotyledon remains attached to each section will result in the eventual formation of two normal identical plants. If more than two are required from the seedling the division must be made before the radicle is five millimetres long. A large number of identical plants can be obtained by cutting back 9 fo 12 months old seedlings to one inch of stem and dividing into four or more fragments. It is necessary to maintain the fragments in a saturated atmosphere. The rooting medium is washed sand.—(*Horticultural Abstracts*, Vol. III, No. 2, Ab. 234.)

* Tunstall, A. C., "A note on the propagation of tea by green shoot cuttings." *India Tea Association. Quarterly Journal*, 1931, pp. 49-51.

ENTOMOLOGICAL CONTRIBUTIONS TO THE STUDY OF THE SUGAR-CANE FROGHOPPER.

By A. Pickles, B.Sc., A.I.C.T.A., F.E.S.

Entomologist, Trinidad Sugar-Cane Investigation Committee.

II.—THE INFLUENCE OF HOST RELATIONS AND OF CULTURAL OPERATIONS IN LIMITING BLIGHT INCIDENCE AMONGST PLANT CANES.—Concluded.

4.—Direct Effect of Cultural Measures on the Insect.

It was mentioned in the introduction, that the absence of blight from plant cane fields appears to be accompanied by a corresponding absence of froghoppers from them. Even when a field has been badly blighted in the course of one year and is replanted during the following wet season after thorough dry season tillage, these canes are seldom or never blighted as plants and large froghopper populations are rarely present in them. On the other hand, dry season tillage of ratoon canes, which usually consists of hand forking between the rows or of implemental inter-row tillage, does not inhibit the carry-over of a large froghopper population.

The absence of adult froghoppers and of blight from plant canes might be largely explicable according to considerations of host selection, as already brought forward, were it not for the fact that the relatively immobile nymphs are also scarce in plant cane fields which, when growing ratoons in the year preceding, were heavily infected. It seems likely, therefore, that the processes of ploughing and harrowing, which usually precede the planting of cane fields, are in some way destructive to froghoppers, or rather to their eggs, since it is chiefly in this stage that the species survives from one wet season to the next. This aspect of the question is developed in the sections which follow.

(a) The distribution of froghopper eggs between trash and soil.

It has been indicated elsewhere (11) that the number of froghopper eggs laid in cane trash is inconsiderable compared with the number laid in soil. More recently, a further series of figures illustrative of this point has been obtained, a series which is representative of the conditions over most of the sugar-growing area of the Colony. These figures are given in Table V.

The trash and soil samples from which the egg counts were obtained were taken from corresponding stools in each case. The data thus show that the eggs laid by the second and later broods during 1931, were chiefly situated in the soil and that with the approach of the dry season, only about one per cent. of the total remained in the trash. Factors concerned with the carry-over of froghoppers from one year to the next may thus be expected to operate chiefly on eggs in the soil. Accordingly, the distribution of eggs in the soil and the influence on this of various cultural operations, have been examined in greater detail.

Table V.

Figures illustrating the distribution of froghopper eggs between trash and the surrounding soil.

Date.	Eggs in Trash.	Eggs in Soil.	Per cent. of Total in Trash.
1931.			
September ..	308	9,120	3.2
October ..	389	16,897	2.3
November ..	694	over 25,146	under 2.7*
December ..	179	23,572	0.7
1932.			
January ..	145	13,574	1.0
February ..	10	4,243	0.2
Total ..	1,725	over 92,552	under 1.8

(b) The natural distribution of froghopper eggs in the soil, in the vertical plane.

Laboratory experiment with artificially prepared soils, shows (11) that froghopper eggs are laid in the uppermost thin layer of the soil. Soils in the cane field, however, present a very uneven surface, which is often covered with large or small clods, and which is constantly changing to a larger or smaller extent under the weathering effects of rainfall, flooding, wind and drought. It is therefore desirable to determine the vertical distribution of eggs in the field in the dry season in order to elucidate the conditions which the eggs have to withstand.

The method adopted involved removing successive one-inch layers of soil from the surface downwards and examining the samples so obtained for eggs. The apparatus employed is shown in Figure 1, A and B. This consists of a hollow cylinder of mild steel, 2½ inches in diameter and 12 inches long. The lower circular edge is sharpened, so that the tool resembles a large cork borer. Slots are cut half-way across the tool at intervals of one inch, and by means of steel plates (Fig. 1 B.) which can be inserted in these slots, the cavity of the tool may be divided into cylindrical compartments, each one inch in height. In use, the tool, without the plates, is hammered into the soil to the appropriate depth and is then removed, bringing with it a core of soil. A plate is then inserted into each of the slots, beginning with the lowest one and a series of one-inch layers of soil, which can be removed separately, is thus obtained. Four such samples are taken from one stool and corresponding layers from one stool are bulked.

* Eggs in soil were so numerous during this month that several soil samples could not be examined to completion.

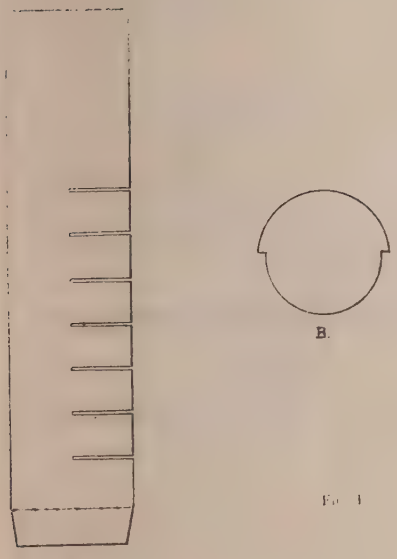
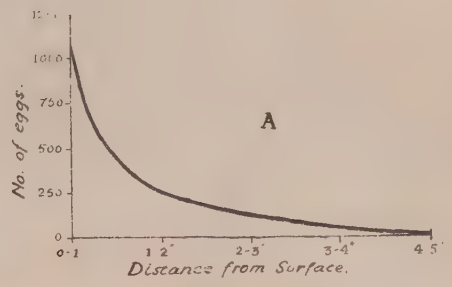


Fig 1



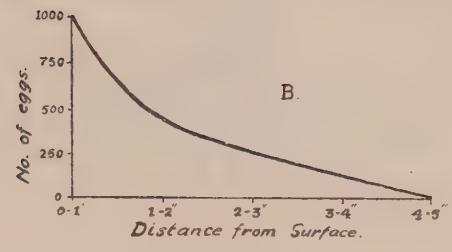


Fig 2

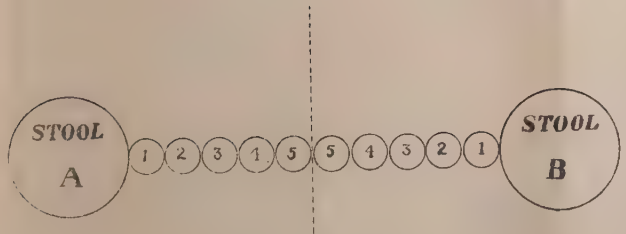
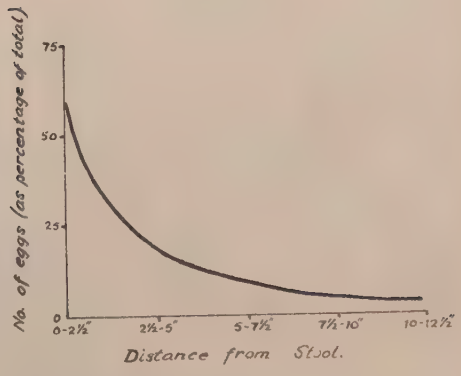


Fig 3

Fig 4



In practice, it was found to be difficult to obtain samples from more than three strata in this way, owing to serious compaction of the deeper layers of soil by the tool. Two independent experiments were performed at different parts of Caroni Estate and details of the results are given below.

The series of samples obtained in this way may be regarded as so many randomised blocks in a field experiment, if the tools to be sampled are selected at random, and the depths at which the samples in the series are taken correspond to treatments. The data may thus be examined according to the "analysis of variance" method described by Fisher and Wishart, 1930 (4). A statement of the results of the experiments is given in Tables VI and VII.

These experiments thus show that there is a significant fall in the density of egg distribution in the soil from the surface downwards, the proportions of the total number of eggs in each stratum being, according to Experiment I.

0-1	.. ..	73.1 per cent.
0-2	.. ..	18.0 do.
2-3	.. ..	8.8 do.

and according to Experiment 2:

0-1	.. ..	58.2 per cent.
1-2	.. ..	25.9 do.
2-3	.. ..	15.9 do.

While the same trend is shown in both cases, considerable variation in the actual proportion of the eggs in a given stratum may thus be expected from place to place.

Variations in the density of distribution of froghopper eggs in the soil, with increasing distance from the surface.

Table VI.

EXPERIMENT 1.

Stool No.	No. of Eggs at a depth of 0-1"	1-2"	2-3"	Total.
1 ..	14	13	1	28
2 ..	21	0	2	23
3 ..	44	25	2	71
4 ..	38	3	1	42
5 ..	32	2	3	37
6 ..	80	4	1	85
7 ..	36	0	2	38
8 ..	57	3	3	63
9 ..	21	0	4	25
10 ..	14	29	15	58
11 ..	38	2	0	40
12 ..	82	42	4	128
13 ..	82	20	8	110
14 ..	142	15	18	175
15 ..	139	49	45	233
16 ..	136	31	8	175
17 ..	14	2	4	20
18 ..	46	16	4	66
Total ..	1,036	256	125	1,417

ANALYSIS OF VARIANCE.

Due to	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (mean sq.)
Stools	17	21,648	1,273.4	3.57459
Depths	2	26,953	13,476.5	4.75447
Error	34	16,511	485.6	3.09269
Total	53	65,112	—	—

$z = 1.6618$

For $p = .05$, with $n_1 = 2$, $n_2 = 34$, $z = .5994$.
For $p = .01$, with $n_1 = 2$, $n_2 = 34$ $z = .8423$.

The effect of depth on egg distribution is therefore significant.

Table VII.

EXPERIMENT 2.

Stool No.	No. of eggs at a Depth of 0-1"	1-2"	2-3"	Total.
1 ..	121	32	11	164
2 ..	71	32	20	123
3 ..	103	36	24	163
4 ..	63	42	86	191
5 ..	92	29	19	140
6 ..	5	4	5	14
7 ..	9	11	7	27
8 ..	33	30	9	72
9 ..	103	62	20	185
10 ..	48	22	2	72
11 ..	27	14	4	45
12 ..	140	68	43	251
13 ..	8	9	6	23
14 ..	18	7	2	27
15 ..	42	18	8	68
16 ..	20	6	2	28
17 ..	28	14	5	47
18 ..	27	3	0	30
19 ..	14	9	2	25
20 ..	43	5	3	51
Total ..	1,015	453	278	1,746

ANALYSIS OF VARIANCE.

Due to	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (mean sq.)
Stools	19	9830.3	517.384	1.64365
Depths	2	31931.4	15965.700	5.07277
Error	38	18659.7	491.045	1.59127
Total	59	60421.4		

$z = 3.4815$.

For $p = .05$, with $n_1 = 2$, $n_2 = 38$, $z = .5994$.
For $p = .01$, with $n_1 = 2$, $n_2 = 38$, $z = .8423$.

The effect of depth on egg distribution is therefore significant.

The soil strata below three inches from the surface were briefly investigated by means of a narrower soil borer. With this tool, a large composite sample, representative of the layer between four and five inches from the surface and weighing about ten pounds, was obtained from the same field which yielded the material for Experiment 1. On examination, this sample yielded one egg only. It seems likely, therefore, that the egg population becomes negligible at a depth of about four to six inches below the surface in the case examined.

Again, active nymphs were found in May, 1932, at Ste. Madeleine, at a depth of over six inches while inter-row forking was in progress. A composite sample was obtained by removing soil from the immediate vicinity of these nymphs, which on examination yielded no eggs. It is perhaps significant that all such nymphs were found at the bases of worm tunnels, and the observation suggests that the nymphs had wandered to these deep positions after hatching.

In Fig 2, A and B, are shown graphically the number of eggs occurring at different depths in the soil from the results of Experiments 1 and 2, assuming that the population approaches zero between four and five inches.

(c) *The natural distribution of eggs in the horizontal plane.*

Experiments were conducted to investigate the frequency of distribution of froghopper eggs with increasing distance from the stool. Two fields at Woodford Lodge Estate were selected for examination in November, 1931, which had been subjected to heavy froghopper attack and in which it was known that a large number of eggs occurred. Soil samples, one inch deep, were taken with sharpened steel cylinders of two and a half inch diameter, according to the scheme illustrated in Fig. 3. A cane stool was chosen at random and samples were taken between it and its neighbours in the adjacent rows on either side. If the stool be called "A" and its right and left hand neighbours respectively "B" and "C" : then, sample 1 consisted of the discs of soil removed from the closest possible proximity to stools A and B. Sample 2 was obtained by removing discs of soil from spots touching the spaces left on removing sample 1, and so on. This brought the possible sites for sample 5 at or near the centre of the inter-row and it was decided always to remove the parts of sample 5 accurately from the centre of the inter-row. Similarly, five samples constituting an "A" series for comparison were removed from the inter-row between stools A and C. When the sampling was completed, a fresh set of three stools was selected at random and the process was repeated, corresponding samples being bulked together. The samples were then prepared as usual and examined for eggs. The results were as follows:—

Table VIII.

The distribution of froghopper eggs in the soil, in the horizontal plane.

Sample No.	No. of Eggs.	Per cent. of Total.	Sample No.	No. of Eggs.	Per cent. of Total.
Series 1.—Results form 4 sets of 5 Stools.					
1	546	56.3	1A	781	77.9
2	168	17.3	2A	137	13.6
3	154	15.9	3A	37	3.7
4	53	5.5	4A	30	3.0
5	49	5.0	5A	17	1.7
Total	970	100.0	Total	1,002	99.9
Series 2.—Results from 6 sets of 3 Stools.					
1	1,026	71.6	1A	273	51.6
2	240	16.7	2A	131	24.6
3	93	6.5	3A	68	12.8
4	65	4.5	4A	36	6.7
5	8	0.6	5A	23	4.3
Total	1,432	99.9	Total	531	100.0

If the mean percentage number of eggs for each zone be obtained from the foregoing figures, the distribution becomes (Table IX):

Table IX.

Sample.	Distance from Stool.	No. of Eggs (per cent.)
	Inches	
1	0-2½	64.3
2	2½-5	18.0
3	5-7½	9.7
4	7½-10	4.9
5	10-10½	2.9

On plotting these values, a regular curve of the form shown in Fig. 4 is obtained. The greatest concentration of eggs thus occurs in close proximity to the stool. Between 2½ and 5 inches, there is a very rapid diminution in the density of distribution and thereafter, a slower but regular decrease. A little consideration will show also, that the absolute population in each circle exhibits the same trend as the concentration. In the case of heavy infestations, however, such as those investigated, eggs are present even in the centre of the inter-row, and there is no zone free from eggs.

Samples taken as above, however, do not include the soil lying between the cane stalks and immediately around the root stock. In order to determine the proportion of the eggs occupying such a position, a separate rough experiment was conducted.

Three stools, shortly after reaping were selected at random at Woodford Lodge Estate, where again it was known that a high egg population existed. The surface one inch of soil within three inches of the cane stalks was carefully removed to form the "soil" sample. Then, with a sharp adze, the recently cut cane stalk bases and the soil between them were pared down to the level of the excavation made by taking the "soil" sample. This part is referred to as the "shavings" sample. On arrival at the laboratory, the soil was washed as completely as possible off the plant matter in the "shavings" sample, and examined for eggs, as also was the "soil" sample. The cane stems and roots in the "shavings" sample were preserved in a moist condition in order to see if nymphs would hatch from eggs not removed by washing. Only three nymphs appeared on this material. The egg counts from the samples were as follows (Table X) :—

Table X.

The distribution of froghopper eggs between stool shavings and the soil immediately around the stool.

Stool No.	No. of Eggs in		Eggs in Shavings as per cent. of Total.
	Shavings.	Soil.	
1	70	69	50.4
2	435	104	80.7
3	110	47	70.0
Total	615	220	73.6

In this case, the experiment can only be regarded as preliminary on account of the small number of samples examined, but the results suggested strongly that the greatest density of egg distribution is in the soil lying between the cane stalks, that is, in the position most inaccessible to routine cultural treatment in ratoon fields. This indication is of especial interest in view of Mr. E. B. Smith's suggestion (13, Vol. III, p. 30), that some form of stool shaving should form part of the ordinary treatment of ratoon canes.

It is hoped that further examination of the effect of shaving will be possible in the near future.

(*d*) *The effect of ploughing on egg distribution.*

The freedom of ploughed fields from froghopper attack in the wet season renders an examination of the effect of ploughing on egg distribution very desirable, for comparison with the effect of other treatments. Data have been collected illustrative of this effect, of which details follow. An indication had been obtained that froghopper eggs deprived of air did not enter into a resting condition, but actually died and the possibility was considered that ploughing might bury the eggs beneath a deeper layer of soil and in this way deprive them of the necessary supply of oxygen.

The method employed in this study was the same as that used in the investigation of egg distribution at different depths around undisturbed stools by means of the steel cylinder. In order that the loose, dry soil of ploughed fields should remain in position when the tool was withdrawn from the soil, it was found necessary to drive the cylinder into the compact soil which had not been disturbed by the plough. This formed a plug at the lower end of the steel tube and prevented the dry soil from falling out. Since the stools had been uprooted by ploughing, the spots for sampling were selected entirely at random.

In the following table, five samples which yielded no eggs at any depth were discarded. Also, on account of the ease with which the sampling tool could be driven into the soil, samples were taken at four successive depths. The results are given in Table XI.

Table XI.

Vertical distribution of froghopper eggs in the soil after ploughing.

Sample.	No. of Eggs at a Depth of				Total.
	0-1"	1-2"	2-3"	3-4"	
1 ..	0	1	4	1	6
2 ..	1	1	1	2	5
3 ..	8	1	8	3	20
4 ..	0	1	0	0	1
5 ..	0	0	1	0	1
6 ..	1	5	2	0	8
7 ..	0	1	1	0	2
8 ..	0	0	1	0	1
9 ..	1	3	0	1	5
10 ..	0	0	1	4	5
11 ..	0	1	1	0	2
12 ..	2	1	1	2	6
13 ..	4	0	1	0	5
14 ..	3	0	0	0	3
15 ..	2	0	0	0	2
16 ..	0	2	2	1	5
17 ..	1	0	0	1	2
18 ..	2	0	0	0	2
19 ..	4	2	1	1	8
20 ..	0	0	0	2	2
21 ..	2	0	3	1	6
22 ..	0	0	2	1	3
23 ..	2	1	3	0	6
24 ..	3	1	1	0	5
25 ..	2	0	0	1	3
Total ..	38	21	34	21	114

Analysis of Variance.

Due to	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (mean sq.)
Stools ..	24	89.04	3.7100	01.6551
Depths ..	3	12.40	4.1333	0.77095
Error ..	72	126.60	1.7583	0.2821
Total ..	99	228.04	—	—

$z = .4274$

For $p = .05$, $n_1 = 3$, $n_2 = 72$, z must equal .5073.

Within the range investigated, the influence of depth is thus not significant.

In this case, there is no indication that the distribution of froghopper eggs in a field which has been ploughed is connected with depth, suggesting that after ploughing, the eggs are distributed at random in the disturbed soil. In the fields examined in the experiment just quoted, the depth of soil disturbed by the ploughing was from 5½ to 6 inches. The hypothesis that ploughing asphyxiates froghopper eggs by burying them thus appears to be untenable.

(*e*) *The effect of chiselling on egg distribution.*

In certain types of cane soil, the use of a tractor drawn chisel is an alternative to steam or tractor ploughing. It is claimed that this implement has certain agricultural and economic advantages over the usual type of plough, though its applicability to different types of soil is perhaps limited.

Some fears have been expressed that the use of the chisel may not be so efficient in the destruction of froghoppers after a serious attack as is ploughing, since the supposed burying effect of ploughing can hardly be expected to be shared by this process. We have seen, however, that there is little evidence to show that ploughing does bury the eggs and consequently it seems possible that chiselling as a froghopper control might be just as efficient.

That this is the case is confirmed by the records of blight distribution from one estate where the vast majority of the plant cane fields is cultivated by the chisel and where there does not appear to have been any increase in the liability of plant cane fields to attack. A very satisfactory demonstration of this is given by the records for the year 1931, when blight in most districts was unusually severe and widespread, including the estate in question. A summary of the records is given in Table XII.

Table XII.

Distribution of froghopper blight between plant canes and ratoons, on one estate where chiselling is practised.

Rotation.	Total No. of Fields.	No. of Fields blighted.	Fields blighted as per cent. of total.
Plants ..	81	8	9.87
Ratoons	75	47	62.66

The following table (Table XIII) shows the effect of chiselling on the vertical distribution of froghopper eggs in the soil.

Within the range investigated, therefore, it is not possible to establish a relationship between the number of eggs in the soil and the depth after chiselling. It appears that the effect of chiselling a field containing froghopper eggs definitely disturbs the latter from their original position and probably distributes them at random within the disturbed soil, thus having an effect comparable to that of ploughing.

Table XIII.

Effect of chiselling on the distribution of froghopper eggs in the soil.

Sample No.	No. of Eggs at a Depth of			Total.
	0-1″	1-2″	2-3″	
1 ..	4	0	7	11
2 ..	13	0	6	19
3 ..	6	4	8	18
4 ..	3	8	0	11
5 ..	5	1	0	6
6 ..	9	6	14	29
7 ..	3	11	7	21
8 ..	3	5	0	8
9 ..	7	2	5	14
10 ..	12	1	9	22
11 ..	3	3	0	6
12 ..	5	0	6	11
13 ..	4	3	11	18
14 ..	15	2	0	17
15 ..	12	0	3	15
16 ..	0	7	3	10
17 ..	1	0	1	2
18 ..	14	8	4	26
19 ..	1	5	9	15
20 ..	10	11	10	31
21 ..	2	0	3	5
22 ..	6	5	5	16
23 ..	8	5	4	17
24 ..	8	12	4	24
25 ..	3	6	8	17
26 ..	12	0	8	20
27 ..	3	5	8	16
28 ..	8	4	5	17
29 ..	7	7	6	20
30 ..	9	3	5	17
Total ..	196	124	159	479

Analysis of Variance.

Due to	Degrees of Freedom.	Sum of Squares.	Mean Square.	½ $\log_e$ (mean sq.)
Spots ..	29	457.00	15.76	0.22747
Depths ..	2	53.42	26.71	0.49123
Error ..	58	823.24	14.19	0.17490
Total ..	89	1333.66	—	—

$z = .3163$

For $p = .05$, with $n_1 = 2$, $n_2 = 58$, $z = .5738$.

The effect of depth on egg distribution within the range investigated is therefore not significant.

(*f*) *The effect of forking on egg distribution.*

Tillage of ratoon fields in Trinidad is not universally practised, but where it is performed, the treatment usually consists of hand forking in the alternate inter-rows after reaping. On some estates, a similar end is attained by mechanical inter-row cultivation. Such cultivation is unable to affect the soil in close proximity to the stools, for forking close to the stool would

delay the work of the labourer by causing his fork to become entangled in the underground cane tissues and in addition, there would be danger of considerable damage to the cane stool itself. As a result, it is found that a collar of undisturbed soil is left after forking around ratoon stools, which may be from two to six inches wide. In addition, the soil between the stems is left undisturbed.

It is shown above that the soil zone containing most of the eggs is that between the cane stems and in the first two inches of soil around the stool. After forking, therefore, most of the eggs in the soil remain in close proximity to the stools and the nymphs which hatch from these with the commencement of the rains are consequently in a favourable position to attack the canes.

Eggs also occur in appreciable number, however, up to the centre of the inter-row and the effect of forking on these more distant eggs has been determined. The methods employed were similar to those used in the study of the effect of ploughing, except that, since the stools in the forked fields were remaining *in situ*, it was possible to sample around these instead of to sample spots entirely at random. Four bulked samples were taken at each depth around each selected stool. Table XIV shows the results of the examination.

It is therefore concluded that the eggs around ratoon cane stools where the beds have been forked are probably scattered at random in the disturbed soil, in much the same way as are the eggs in a ploughed or chiselled field. The important difference between forking and ploughing would appear to lie in the fact that in the latter case, the whole field is cultivated, while in the former, a zone of untilled soil is left around each stool.

(*g*) *The effect of uprooting cane stools in ploughing.*

In the previous section, it was suggested that the failure to till the soil zone immediately around ratoon stools when the fields are forked might be of great importance in the survival of froghopper populations over the dry season. When fields are ploughed and harrowed during the dry season

Table XIV.

Effect of forking on the distribution of froghopper eggs.

Sample.	No. of Eggs at a Depth of				Total.
	0-1″	1-2″	2-3″	3-4″	
1 ..	22	8	6	1	37
2 ..	0	5	5	0	10
3 ..	1	19	2	1	23
4 ..	3	0	1	0	4
5 ..	16	21	1	1	39
6 ..	0	3	0	1	4
7 ..	5	8	4	0	17
Carried forward	47	64	19	4	134

Table XIV.—*Continued.*

Effect of forking on the distribution of frog hopper eggs.

Sample.	No. of Eggs at a Depth of				Total.
	0-1″	1-2″	2-3″	3-4″	
Brought forward	47	64	19	4	134
8 ..	24	2	2	13	41
9 ..	46	19	12	4	81
10 ..	0	3	12	11	26
11 ..	44	17	11	1	73
12 ..	9	12	24	1	46
13 ..	21	11	1	0	33
14 ..	7	4	0	1	12
15 ..	1	1	4	1	7
16 ..	6	0	7	0	13
17 ..	3	6	20	19	48
18 ..	2	0	0	6	8
19 ..	10	15	12	30	67
20 ..	5	29	2	1	37
21 ..	4	34	30	5	73
22 ..	4	0	3	6	13
23 ..	9	14	44	33	100
24 ..	2	11	2	2	17
25 ..	19	12	9	3	43
26 ..	16	11	2	2	31
27 ..	9	8	21	32	70
28 ..	2	1	14	19	36
29 ..	1	48	34	13	96
30 ..	21	4	3	0	28
31 ..	16	15	7	8	46
32 ..	0	9	8	4	21
33 ..	32	28	2	1	63
34 ..	4	8	8	2	22
35 ..	21	53	7	58	139
36 ..	8	1	5	3	17
37 ..	2	1	1	0	4
38 ..	9	14	15	1	39
39 ..	5	11	11	31	58
40 ..	10	8	4	0	22
41 ..	6	17	8	8	39
42 ..	4	21	4	0	29
43 ..	3	2	12	4	21
44 ..	33	6	14	5	58
45 ..	2	8	3	1	14
46 ..	0	14	3	0	17
47 ..	15	9	5	3	32
48 ..	3	1	2	0	6
Total ..	485	552	407	336	1,780

Analysis of Variance.

Due to	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (mean sq.)
Stools ..	47	10595	225.42	1.55764
Depths ..	3	449.5	149.83	1.35344
Errors ..	141	12290	87.16	1.08257
Total ..	191	23334	—	—

$z = .2709$

For $p = .05$, with $n_1 = 3$, $n_2 = 47$, $z = .4787$.

The effect of depth on egg distribution is therefore not significant.

in preparation for re-planting, the stools are uprooted and a greater or smaller mass of soil adheres to them. It is therefore of interest to determine the number of froghopper eggs contained in these masses of soil and also their fate on the commencement of the following rainy season.

During the dry season of 1930, an attempt was made by one estate to remove froghopper eggs as completely as possible from ploughed fields, by hauling out the ratoon stools and burning them. An examination of the stools so removed, however, disclosed the presence of very few eggs (11, p. 467), so that this procedure did not seem to be satisfactory. Subsequent observation, it may be added, on similarly treated stool fragments has confirmed this. The stools examined had been well shaken together to remove much of the adhering soil, as it was found that otherwise the material would not burn, and it seems that most of the eggs are also removed in this way before the stools leave the field.

When the soil adhering to uprooted cane stools is examined for froghopper eggs without previously beating the stools, a rather large number of eggs, may often be found, as has been shown by observation during 1931. Since stools are usually split by the action of the implements, it is not possible to give the egg counts per stool and the populations are accordingly expressed as the number of eggs per pound of soil. For comparison, the number of eggs per pound of soil from samples taken before the fields were ploughed is also given in Table XV.

The egg populations in these fields were moderate only and, since the soil adhering to a cane stool after ploughing may exceed fifty pounds, it follows that well over a hundred eggs per stool may be left in close intimacy with their host plant after such cultural treatment. Further, since such stools will not normally take root again, it follows that a significant part of the froghopper population may fail to survive as a consequence of the death of the host, resulting in the absence of food for many nymphs which hatch in the following wet season.

Not infrequently, however, it happens that certain of the uprooted stools do take root again, and if the preceding arguments be correct, it should be possible to find a significant froghopper population on such stools during the period of first brood activity. That this is the case is shown by the detailed incidence records which are kept by the author's division for certain sugar estates. During the emergence of the first brood of 1932, no fewer than fourteen tilled fields on one estate, which had been left to fallow, contained froghopper nymphs on old ratoon stools which had taken root again. In most cases, the numbers of the insects were small, about two to ten per stool, but in the case of two fields where the incidence during the previous year had been exceedingly high, the populations were from sixty to eighty per stool. The dispersal of froghopper eggs in the dry season from close proximity to their host plants, which occurs during tillage in preparation for the replanting of cane fields, thus appears to be of paramount importance in restricting froghopper abundance and these considerations suggest that in the treatment of infested ratoon fields, every effort should be made to break up the concentration of eggs around and in the stool during the dry season. It seems possible that this end might be attained by a process of stool shaving, if the soil around the stool also be treated during this operation and it is hoped to test the possibilities of this in a critical field experiment.

5. Factors causing Froghopper attack in Plant Cane Fields.

It has been shown that, although plant canes do not appear to be markedly *resistant* to attack by froghoppers, nevertheless blight appears on them to a much smaller extent and milder degree than on ratoon canes. The evidence goes to show that this comparative freedom from blight is the result of a smaller liability to mass attack by froghoppers due, at least in part, to the following causes:

(1) The thorough cultivation which is given to most cane fields before planting, distributes the eggs over the fields and does not leave them concentrated about the host plant. This places the resulting nymphs at a considerable distance from their food and accordingly diminishes their chance of survival. In the light of certain experiments now partially concluded, it also seems possible that the tillage of soil containing froghopper eggs may bring about an increased mortality of the eggs themselves through exposure to unfavourable conditions of temperature and humidity, an aspect of the study which it is hoped to develop later.

Table XV.

Field.	Samples From Uprooted Stools.			Samples Prior to Ploughing.		
	Weight.	No. of Eggs.	Eggs per lb. Soil	Weight.	No. of Eggs.	Eggs per lb. Soil
A ..	41 lb.	110	2.68	12¼ lb.	222	18.1
B ..	54 lb.	132	2.44	10 lb.	148	14.8

(2) Although there is no evidence to show that plant canes do not afford an attractive or adequate diet for froghoppers, it is seen that small canes, both plants and ratoons, are avoided to a significant degree by froghoppers, due to tropic or habit response on the part of the insects. Small plant canes during their first year of growth are thus protected to a great extent against invasion by froghoppers, with the result that plant canes commence their second wet season of growth with a small egg population and are consequently unlikely to develop large froghopper populations.

Cases do occur, however, in which plant canes are attacked by large froghopper populations and are quite badly blighted and we are now in a position to explain how this rather exceptional condition may arise. The first, and probably most usual cause of serious blight in plant canes, is invasion of fields of well grown plants from breeding grounds external to them. A case of this has been discussed above where blight in two plant cane fields at Ste. Madeleine could be traced to an invasion from a grassy railway bank. In this case, both young and old plants were affected but the froghopper populations were heavier and the blight was more intense in the taller plant canes than in the less well grown fields. Attention to this cause of blight has already been drawn by various authors (Smith, 14, Hardy, 5).

Blight may also occur in plant cane fields when large numbers of ratoon stools survive in them. In general, this is not of common occurrence in Trinidad owing to the prevailing practice of wet season planting, in the course of which, any surviving ratoon stools are removed when the final preparations (forking and drilling, etc.) for planting are made. The plants and ratoons do not grow up together under this system and the surviving froghopper population tends to be eliminated with the old ratoon stools. There is often a greater tendency for the survival of ratoons in plant cane fields when dry season planting is practised. In this case, the fields are planted without any period of bare fallow, either with or without previous cultivation of the land. Sometimes the cane "seed" is inserted between the ratoon stools soon after reaping, and the latter are removed after the commencement of the rains when the fields are forked. With the commencement of the rains, froghoppers emerge on the ratoon stools and may cause blight over the whole field before removal of the ratoon stools is possible. Blight in such cases is usually of little consequence, owing to the good powers of recovery of the cane and the small chances of attack by subsequent broods, which usually seek the more favourable conditions offered by taller-canes after the ratoons have been stumped out, though occasionally the effects of the attack may persist when conditions for recovery are poor and when the initial attack is particularly severe. When fields are tilled before dry season planting, the dangers of the survival of a froghopper population are not so great, as carry-over is chiefly dependent upon the few uprooted stools which survive. In both cases, however, there is greater tendency for the survival of froghoppers on ratoon stools in the neighbourhood of plant canes than when wet season planting is practised. It may therefore be regarded as somewhat undesirable to plant in the dry season, fields which are known to be often subject to froghopper attack, a fact which is generally, though not universally recognised in Trinidad.

C. B. Williams has already shown that, in years when froghopper blight is very severe and widespread, the attacks are less discriminate than in other years, although the same tendencies may be observed (16, p. 115). Thus, in the case of plant canes, a greater proportion of the fields may be expected to show blight in such a year than in a normal year, but the proportion of plant canes affected will still be less than the proportion of ratoon canes. One of the characteristics of a year of marked blight seems to be that factors are at an optimum for froghopper reproduction, as might be expected (*see* part 1 and also 10, p. 402); that is, larger populations than usual are able to develop from few parents and the difference between a bad year and a good one is thus not entirely dependent upon the conditions for recovery of blighted canes. It has been shown above that even in fields of young plant canes, a small population of froghopper eggs is frequently present in the dry season. The progeny of those which will survive are more numerous in a year of widespread blight. Consequently, in certain plant cane fields, the survivors will be sufficiently numerous to bring about noticeable symptoms of blight. Where the fewest eggs occur, however, the fewest survivors may be expected in general and so, although blight may develop in a certain number of plant cane fields, it is this category nevertheless which will include the greatest proportion of cases of freedom from attack.

The author is indebted to the managers and other officials of the several sugar estates in Trinidad for their ready hospitality and co-operation in this work, particularly to Mr. W. H. Gilbert, of Caroni Estate, Mr. J. H. Taylor, of Orange Grove and Mr. E. B. Smith, of Woodford Lodge. Especial acknowledgment is made to Mr. P. E. Turner, Soil Chemist to the Sugar-Cane Investigation Committee for his help and advice with regard to the statistical treatment of experimental data.

6. Summary.

1. Data are given, illustrating the relatively small occurrence of froghopper blight in plant cane fields in Trinidad, as compared with ratoon fields.

2. Experimental evidence is given in support of the view that this difference is not determined by any superior powers of resistence to blight on the part of plant canes.

3. It is shown that, while young plants seem to be unattractive to invading froghoppers, this property is not shared to the same extent by older plant canes, which seem to be almost as attractive as ratoons. The evidence shows that the essential differences are associated with growth characters, such as stature, rather than with trophic selection on the part of the insects.

4. Data are given which show that factors concerned with the survival of froghopper populations from one wet season to the next will operate chiefly on eggs in the soil, since the number of eggs in the trash, particularly towards the end of the year, is small.

5. Detailed figures are given illustrative of the distribution of froghopper eggs in relation to the host plant, and of the effect on this of the usual cultivation measures, *viz.*, ploughing, chiselling and forking. The results show that the normal preparation of land for replanting, disperses the eggs from an original concentration around the stools of the host, an effect which does not result from the usual treatment of ratoon fields. The eggs do appear to be buried beneath a deep layer of soil by any tillage operation studied.

6. Cases of the occasional infestation of plant cane fields are considered. The causes of this include the invasion of fields from external breeding grounds, the survival of ratoon stools in fields of plant cane and a raising of the general level of survival of froghoppers in years of particularly severe and widespread blight.

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CLEANING CITRUS FRUIT.

This is the title of a *Bulletin* issued by the California Fruit Growers' Exchange in which it is stated that in view of the inability of many of the smaller packing houses in California to clean their fruit successfully, an investigation of cleaning methods was undertaken. This included in its scope an analysis and comparison of the numerous detergents in use, a study of the various types of foreign matter on the fruit and the ease of their removal, a survey of washing equipment and a comparison of the efficiency of various washing units. The improved appearance of fruit washed in soft water alone justifies the expense of a softener. A table of comparison is given of the various methods used for softening water containing 165 parts per million of hardness and of the amounts of various soap products required to bring 100 gallons of water to a suds point. The composition of a number of soaps and soap powders is described, and a study is made of the relative efficiency of the various alkaline cleaners or soap aids, as also of soap products, 24 commercial brands of the latter being tested. The interesting fact emerged that the efficiency of the soap products was more or less proportional to their anhydrous soap content. The bulletin concludes with instructions as to the best method to be followed to ensure thorough cleaning of extremely dirty fruit.—(*Horticultural Abstracts*, Vol. III, No. 2, Ab. 221.)

REVIEWS.

The Farm and the Nation.

By Sir E. John Russell, D.Sc., F.R.S. *George Allen & Unwin Ltd.*, London, 1933, pp. 240, price 7*s.* 6*d.*

In this volume Sir John Russell discusses the possibilities of developing British Agriculture with a view to using it as a possible means for increasing national wealth and relieving the unemployment problem.

The major part of the book deals with the nation's sources of food supply, a subject which is treated both from the British and Empire standpoints. It is shown that of the nation's food bill, which is approximately £639,000,000 Great Britain has been supplying 39.3 per cent., the Empire 21.6 per cent. and Foreign Countries 39.1 per cent. It is believed that all-British supplies of milk, potatoes, lamb, mutton and cheese could be secured and that Great Britain could be nearly self-supporting, but not quite, in bread and fruit. With regard to beef, bacon, butter and eggs, the problem appears to be more difficult although it would not be impossible for the nation to become self-sufficient in these respects. With regard to consumption, two important changes which " may be far reaching in their effects " are noted: (*a*) that less of the British nation's food is fresh and more is chilled, frozen or preserved than before the War, and (*b*) that much more fruit and a fair amount more sugar than before the War is consumed.

In a fascinating chapter on " our farming land, how we now use it " the reader is familiarized with the remarkably diversified conditions of British farming. In recent years, the tendency for farmers has been to convert arable into grass land and to turn more to dairying, poultry, vegetables and fruit as avenues of production.

In the closing chapters of the book, the author, after referring to some of the British farmer's difficulties, goes on to examine new lines of possible agricultural development. Reference is made to the effect of recent scientific achievements on crop and animal production, to new forms of output (mechanised farming) and to ways and means by which wastes and losses might be reduced, the efficiency of labour increased, and production and marketing better organised. Improved methods of production can, however, only be used as a means to an end, but in the case of British Agriculture it does not appear as if that end had been clearly defined. In fact, according to the author, the purpose of British Agriculture is very vague, although he thinks that it might have three objectives: (*i*) the production of more food for the nation, (*ii*) the provision of higher wages and higher profits for people working on the land, (*iii*) the settlement of a larger population on the land. These three purposes are quite distinct and while any one of them may be aimed at with some chance of success " to aim at all three probably means missing them all ". The author concludes by suggesting that British Agriculture might be treated with a view to organising it for greater food production or greater employment, or alternatively leaving it to work out its own salvation. The community must choose and must do so soon, or otherwise it will not be possible to get far with the solution of the problems involved.

The book presents a clear and concise picture of British Agriculture as it exists to-day. The modern aspects of its problems have been stressed and should be of particular interest to those who wish to keep up-to-date with the recent developments in British farming.

G.G.

* * *

The Scientific Feeding of Animals.

By O. Kellner, translated by W. Goodwin. *Messrs. Duckworth*, 3, Henrietta Street, London, W.C. 1926. pp. 328, price 8*s.* 6*d.*

This is no new edition of Kellners' book, but it is still one of the best books for the stock-feeder. It is divided into three parts:—Part I deals with the composition, digestion, and utilisation of feeding stuffs: Part II treats the foodstuffs; their properties, conservation, preparation, and applicability: while Part III deals with the feeding of domestic animals under the conditions usually found in practice. The book is of great practical value, and although the ideas are based on the chemical composition of foodstuffs and the chemistry of digestion, the scientific aspect is treated in a simple and concise manner. While almost all the research work quoted has been carried out in temperate climates, the tropical agriculturist has no better guide, since the fundamental ideas on nutrition have not been investigated to any great extent under tropical conditions. It is a book worthy of the highest recommendation, and no part of it could be said to be out of date.

D. W. D.

The pupils receiving training at the Experiment Station in Dominica underwent an examination during the month of July. The results were reasonably satisfactory. Much improvement is to be recorded in the attention given to the training of these boys during the last 12 months.

Seeds of a small Shallot onion from South India and of the Dhulia onion from India have been received in the West Indies. Previous experiments with the latter onion have proved promising in Montserrat where they have flowered and seeded.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Process used in Refining Sugar at Mercedita, using "Suchar". *By J. R. Junghans.*

After weighing, the raw sugar is elevated to the mingler, where a thorough mixing is made with wash-syrup, the magma obtained being dropped to the centrifugals where it is washed to 99° purity and No. 10 colour. These washed crystals are dropped into a scroll below, and conveyed into the melter, in which they are dissolved in sweet-water.

In the melter (diam. nine feet) the solution is kept at 60° Brix. and No. 5 colour, being thermostatically controlled at 180°F. It is then pumped up to a storage tank on the top floor of the refinery, from which it is drawn to the carbon mixing tanks of 3,000 gallons equipped with stirring arms and steam nozzles for direct heating this being also thermostatically controlled at 150°F.

Carbon sludge of (10°Bé.) is elevated to the carbon measuring tanks (1,600 gallons) from the carbon house, by means of a montejus operated with compressed air or steam, pumps being incapable of standing up to this work. Approximately 2 lb. carbon ("Suchar") per 100 lb. of refined sugar are used; the mixed carbon and liquor is pumped by means of open impeller centrifugal pumps, through "Auto" filters, at a pressure of 20 to 80 lb. per square inch.

"Auto" filter operation is as follows: Carbon and liquor is pumped through, and the filtrate is circulated back to the mixing tank from which it was pumped until it runs white and clean. After three tanks of liquor with their allotment of carbon have been pumped through the "Auto" the carbon and liquor left in it are discharged to a fourth tank.

Then the filter is filled to one quarter its capacity with hot water, boiled and agitated, removing all the carbon from the leaves and sterilizing the filter, following which the contents are discharged to the fourth tank, mixed with liquor and pumped through the same filter without additional carbon. The white filtrate passes from the "Auto" filter through a bronze spool which always discharges the liquor downward, and in full view of the operator whilst the filter revolves at three revolutions per minute.

When the fourth tank has passed, the filter is blown out with compressed air of 25 to 30 lb. pressure and the sweetening off of the carbon begins as follows: Hot water of 180-200°F. is pumped through the filter, while revolving, until the density of the discharge has dropped to 1° Brix., hot, when the filter is dropped to a sludge tank. Fresh hot water is added to the filter-cloths, thoroughly sterilized by boiling. This process is repeated four times, after which the filter is ready for the next filtering cycle.

White liquor from first filtration is collected from the filters and conveyed into mixing tanks the same as used for mixing carbon and liquor. To it is added 3 lb. of "Super-Cel" per tank, where it is agitated and heated to 175°F. and pumped through an "Auto" pre-coated with 100 lb. of "Super-Cel" per cycle of 200 tanks. The filtrate is circulated until it runs clear and white before passing additional liquor. This second filtration, eliminates small particles of carbon which may have passed through the first carbon filtration.

Lastly, the liquor goes to a triple effect, where it is concentrated from 54 to 63° Brix. and is delivered to the pan storage tanks. Four strikes are boiled, the run-off from the first being boiled to a second strike, so on to the fourth. Two strikes of first yield one of second and two of second one of third and two of third one of fourth. The run-off of the fourth strike with a purity of 92° is returned through the transfer scale to the raw sugar pans to be re-boiled into 96° sugar. After the centrifugals the sugar goes to a Hersey plant. Mercedita refinery last crop produced about 110,000 tons of "Snow White" refined sugar.

After the exhausted carbon has been washed, it is dried in Suchar open dryers and revivified in special Suchar electric furnaces, heat being applied by means of a current of 220 volts passing through electrodes located to distribute the heat necessary to bring the temperature to 900°F.—(*Inter Sugar Journ.*, Vol. XXXV, No. 416, p. 324.)

* * *

Effect of Clarification on Quality of Raw and Plantation White Sugars. *C. A. Fort and C. F. Walton, Jr.**

Data obtained from small-scale clarifications and sugar boiling experiments conducted during 1930 in Louisiana are reported. Juice obtained from a 16-roll tandem was clarified in the laboratory by various methods under carefully controlled conditions, the resulting clarified juices being boiled to syrup and finally to raw or whites. The influence of the method of clarification was measured at all steps in the process, the results being tabulated.

Liming v. Sulphitation.—A quantity of whole mill juice was divided into two parts, the former being lime-defecated, and the latter sulphured with approximately 0.3 grm. of SO_2 per litre before liming. There was nearly a 40 per cent. decrease in turbidity and a corresponding increase in the filtrability of the sugars produced from the lightly sulphured as compared with the unsulphured juice. But a much improved effect was obtained with 0.6 grm. of SO_2, the decrease

* Bureau of Chemistry and Soils, Washington, D.C.

in colour being 55 as compared with 10 per cent. only with the 0.3 grm. In refining whites with the use of carbon, a saving of this material is to be effected by the heavier sulphuring.

Phosphoric v. Sulphur.—In another series of experiments whole mill juice was divided into two parts, 0.6 grm. of SO_2 per litre being added to the first previous to liming, while to the second the equivalent amount of P_2O_5 was added before liming. Judging by the comparative colours and turbidities of the syrups and sugars resulting from juice thus clarified the results using sulphur were a little better than those using phosphoric acid, but the latter gave a sugar of decidedly better filtrability and of slightly lower ash content.

Liming Methods.—A number of juices were all sulphured to the same degree, but limed differently, viz.: in the cold as usual, using thin milk; and at 60 and 70°C. with lime sucrate. In these tests the outstanding result was that the use of sucrate gave clarified juices of greater clarity, though a greater volume of mud resulted than with milk, and the syrups had somewhat lower ash and lime contents.

Overliming before Sulphuring. — Samples of juices were overlimed and sulphured, instead of first sulphuring and then liming, and the conclusion drawn that in the case of the immature juices milled in Louisiana this is a faulty procedure. Sulphuring before liming gave definitely better sugars.

Use of Carbon.—Four lots of double-crusher juices were divided into two parts and clarified separately. After sulphuring, the samples in one series were treated with 0.2 per cent. of activated carbon in the cold for 30 minutes. It was concluded that such sulphuring eliminates 40 per cent. of the colour, and a further 20 per cent. elimination is obtained by the carbon addition.

Syrup Treatment.—Lastly, it was concluded that an important factor in improving white sugar quality is the flocculation of non-sugars by the action of high temperatures on the effect syrup, followed by adequate settling, or preferably by filtration. — (*The Inter. Sugar Journ.*, Vol. XXXV, No. 416, p. 323.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Weed Distribution by Chemicals.

Amongst the many burdens which beset the farmer may be included the spread of weeds, owing mainly to the high cost of keeping the land clean by hand in relation to the value of the crop. It is therefore of wide interest that a new method of weed destruction by spraying with sulphuric acid is under trial on a considerable scale, which promises a cheap remedy for the evil, at all events so far as such plants as charlock (*Brassica sinapis*) and a few other prevalent weeds are concerned. In the past, sulphates of copper and of iron have been used for this purpose with effect, but the ideal conditions for their use, namely, 24 hours of fine weather following a humid day for the application, were too difficult to realise in practice. When using sulphuric acid, only an hour or so of dry weather at the time of spraying is essential.

Spraying with sulphuric acid originated in France, being largely due to the pioneer work of Rabaté, begun in 1911, and it has developed so rapidly that at present several hundred thousand acres are treated annually, involving in 1931 the use of 27,000 tons of acid, whilst some 20 French manufacturers produce suitable spraying machines for its application.

The work in England has been fostered by the National Sulphuric Acid Association with the co-operation of the School of Rural Economy in the University of Oxford, and it has now reached a stage when it has been handed over to the acid-making industry for practical development. This summer several thousand acres have been sprayed with uniform success and the farming fraternity has evidenced a considerable interest in the novel process.

The method of application is a simple one; commercial brown oil of vitriol is mixed with water to give a solution varying from seven to ten per cent. in strength, which is sprayed over the land from a suitable machine, either horse or motor-drawn, with acid-resisting parts. It is preferable for the spraying to be done by contract and thus with men used to handling acid, the farmer supplying the necessary traction. About 100 gallons per acre is the normal amount to spray, but the quantity depends upon the size of the charlock, and it is increased up to 150 gallons per acre when advisable.

The time of spraying depends on the size of the plant and not on the actual time of year. The most favourable moment is when the charlock is in its four-leaf stage, all the seeds having well germinated, but it is effective even when the charlock is several inches high. In a normal year some five to six weeks are available for spraying so that a contractor can organise his operations so as to keep his machines occupied by moving them from early to late growing regions.

The object of the spray is to kill the charlock, which may turn completely brown within twenty minutes of its application, without harming the cereals. The spray is not selective in its action, which is due entirely to the difference in the physiology and morphology of the two plants. The outer skin of the cereal is thick and not easily penetrated by the acid, which slips off the smooth vertical leaves, except at the tips of the leaves which turn brown, whilst the tender growing point is protected by the leaves wrapping round it. The skin of the charlock is easily penetrated as the acid adheres to the open, broad, hairy and

more or less horizontal leaves, and the tender growing point is exposed so that the tissues are plasmolysed by the acid and eventually destroyed. In sunshine the action takes place so quickly that within an hour of spraying, the whole field turns brown, a quite alarming sight: in a few days the cereal recovers and it soon presents the healthy and luxuriant appearance which normally follows a top dressing of a nitrogenous fertiliser.

The cost of spraying is of the order of 12*s.* 6*d.* to 15*s.* per acre, depending on the acreage treated on any one farm: it will be even less when a contractor is fully occupied in a particular district, as much of the cost is occasioned by the transport of the machine. Some 30 per cent. of the cost is due to the sulphuric acid, the carriage of which is also costly. The actual benefits of spraying in the way of increased crop have not yet been fully established: they are claimed to amount in value to so much as £2 to £3 per acre in the most favourable cases. The weeds themselves remove nutrient matter from the soil and they crowd the cereal plant, reducing the crop; when killed by acid, their organic matter is returned to the soil, whilst it is probable that the acid itself may have some effect in increasing soil fertility by accelerating nitrification, though there is no positive evidence on this point.

There is both the immediate gain of an increase in crop and also a reduction of weeds which renders future cultivation more easy: it is stated that, on the Continent, spraying for three or four seasons in succession has resulted in periods of definite freedom from weeds.—(*Nature*, Vol.132, No. 3325, pp. 122, 22nd July, 1933.)

* * *

Agriculture and Milk Supply.

In *Nature*, Vol. 131, 29th April, 1933, p. 605, Professor H. E. Armstrong comments on the importance of the milk industry. The present tendency in food supply is to revert too much to canned foods, and the fact is often overlooked that fresh milk is the one and only complete food known to man. In Britain the medical profession has been afraid of the possibility of spread of tuberculosis, and this fear has prevented the encouragement of increased milk consumption. According to Professor Armstrong, the only chance of eliminating tuberculosis and similar diseases is by scientific feeding, since deficiency of any one food factor is known to cause disease. In one region in New Zealand the animals suffer from a recognized deficiency in iodine: in another, from lack of iron. In Britain, animals often suffer from want of available iron and calcium, while Australian and South African soils are known to be greatly deficient in phosphate, potash, and lime.

Proof has been obtained from experiments on animals that health is greatly influenced by feeding, and that properly fed animals are little, if at all, subject to bacterial infections. Minor deficiencies may not be easily followed up, but in the long run their effects may be deep-seated.

The Effect of Climate on the Composition of Pasture Plants.

Apart from the influence of soil type, stage of growth, and fertilisers, it appears that pasture species grown in tropical and sub-tropical climates are lower in protein and insoluble ash than those in temperate climates.

In tropical and sub-tropical climates the growth of pasture is rapid, and the plant frequently approaches maturity a few months after the onset of the wet season. In cool temperature or winter rainfall climates, growth proceeds much more slowly, and the reproductive stage is reached only after many months of slow vegetative growth. Another habitat factor that may affect the growth rate is the length of day. It is known that short day types of plants are found in tropical regions and long day types in polar and cold temperate regions. It has been shown that in temperate regions the pasture plants are of a type that form reproductive organs only during periods of long days, but these long day types of plants may be kept in the vegetative stage by exposing them to short day conditions.

With regard to mineral uptake, Richardson *et al.* have shown that in pasture plants in South Australia the rate of absorption of nitrogen and phosphoric acid is much greater in the early vegetative stages than is the rate of synthesis of organic matter. On the other hand, the rate of carbon assimilation is partly dependent upon the area of green leaf surface, and as this normally increases till the approach of flowering, the rate of carbon assimilation correspondingly increases and attains a maximum shortly before this stage. Thus the maximum rate of nitrogen and phosphorus absorption on the one hand, and carbon assimilation on the other, occur at two different periods of the plant's development. As a consequence, the percentage of nitrogen and phosphorus, expressed in terms of dry matter, gradually falls from a maximum value in the earliest vegetative stage to a minimum value at maturity.

In temperate regions and winter rainfall climates a long period of slow vegetative growth procedes the reproductive phase, and it is probable that under such conditions the normal pasture could secure the necessary nitrogen and minerals from the soil at a sufficiently rapid rate to keep pace with the somewhat slow photosynthetic activity of the plant, except on the poorest types of soil and except during late spring or early summer when the flush of growth occurs. Under tropical conditions, however, photosynthetic activity continues at a relatively high level, with the result that the nitrogen and phosphorus content, and to a less extent the silica-free ash, will be comparatively low. (*Imp. Bur. of An. Nutrition.* Occasional Communication No. I. by A. E. V. Richardson.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign. s. d.	*Preferential.* s. d.
27th July ..	5 3¾	10 0¾
3rd August ..	5 1½	9 10½
10th August ..	5 0¾	9 9¾
17th August ..	4 9	9 6
24th August ..	5 1½	9 10½
31st August ..	5 1½	9 10½
7th September ..	5 6¾	10 10¾
14th September ..	5 4½	10 1½
(15*th Sept.*, 1932) ..	5 10½	10 7½

Markets have generally displayed a sluggish tendency during the period under review, very quiet conditions having prevailed on both sides of the Atlantic while there has only been some small dealings in Raws. The fall in price in the middle of August was attributed to unsettled conditions in Cuba coupled with the failure of the Washington Conference to agree on a quota plan. The position in the latter respect subsequently showed promise of improvement and as a result of increased buying by the trade and by consuming interests raw values advanced substantially.

* * *

COFFEE.—Demand for fine Jamaica and Costa Rica has been good—at 123*s.* and 130*s.* for Costa Rica, and 206*s.*, 208*s.* and 228*s.* for Jamaica. Stocks of East African coffees are reported to be higher than last year, Kenya being quoted at 65*s.*, 70*s.*, and 75*s.*

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	d.
26th July	$3\frac{3}{16}$
2nd August	$2\frac{13}{16}$
9th August	4
16th August	$3\frac{13}{16}$
23rd August	$3\frac{23}{32}$
30th August	$3\frac{3}{4}$
6th September	$3\frac{11}{16}$
13th September	$3\frac{19}{32}$
(14*th Sept.*, 1932)	$2\frac{11}{16}$

After showing some activity early in August the market has become quiet and rather featureless. The developments in America where the main objective has been to bring about an increase in retail sales, are being watched closely. The July consumption figures are 50,184 tons and the consumption per working day at 2,007 tons constitutes a new record.

COCOA.—Since last writing the cocoa market has been very dull. Shipments from the Gold Coast have been very large, the bulk going to America. For the first half of August they totalled 10,789 tons against 6,165 tons for the whole of August, 1932. The total crop from 1st October to date (15th August) is 230,637 tons against the total crop 1st October, 1931, to end of August, 1932, 198,522 tons. The statistical situation evidently is leaving an impression upon the market that prices will be no better for the next season but under the present unprecedented World conditions however, the unexpected often happens and thus some of the operators who are working at lower prices at present may one day have a nasty shock. Accra cocoa may be quoted at 24*s.* and locally $5.30 a fanega is asked for Plantation.—(*By courtesy of The Cocoa Planters' Association of Trinidad, Ltd.*).

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
28th July ..	6.47	8.48
4th August ..	6.25	8.32
11th August ..	5.90	7.96
18th August ..	5.66	7.63
25th August ..	5.71	—
1st September ..	5.82	—
8th September ..	5.38	—
15th September ..	5.49	—
(16*th Sept.*, 1932) ..	5.88	8.75

Price movements have generally been unsettled and nervous, the general disposition being to stand aside and await developments in America. With regard to West Indian Sea Island there has been improved enquiry at steady prices, sales including Monserrat, St. Kitts and St. Vincent being recorded at 11½*d.* to 14*d.*

* * *

COPRA.—The market is easier and West Indian f.m.s. is now quoted at £11 2*s.* 6*d.* for September, c.i.f. London—(*West India Committee Circular*, 17th August, 1933.)

* * *

BANANAS.—Jamaicas continue in fair demand and are unchanged at £17 15*s.* per ton delivered London, and £17 10*s.* delivered nearest station. Brazilians are in moderate demand and unchanged at £19 delivered nearest station.—(*West India Committee Circular*, 17th August, 1933.)

* * *

LIME PRODUCTS.—*Lime Oil.*—There are sellers of Handpressed at 47*s.* 6*d.* but no demand. There is rather more enquiry for Distilled on the spot and, with selling pressure released, the price has improved to 29*s.* 6*d.* *Lime Juice.*—There are probable buyers of Concentrated at £4 10*s.* 0*d.* c.i.f. There is more activity in Raw and business has been done at 2*s.* 3*d.* to 2*s.* 6*d.* for good to fine. (*West India Committee Circular*, 17th August, 1933.)

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

COLLEGE NEWS BULLETIN

OCTOBER, 1933.] [No. 4.

COLLEGE NEWS.

The 1933-34 College Session opens on Monday, 2nd October.

* * *

Mr. G. Evans, Principal, returned to Trinidad by s.s. *Carare* on 17th September.

* * *

Mr. R. E. D. Baker, Lecturer in Mycology, paid short visits to St. Lucia and St. Vincent at the beginning of July.

* * *

Mr. G. A. Jones, Acting Commissioner of Agriculture, will represent the College at the forthcoming Fruit and Vegetable Conference in Jamaica.

* * *

Mr. H. A. Ballou, Commissioner of Agriculture and Professor of Entomology, and Mrs. Ballou returned from a holiday in Barbados by s.s. *Ariguani* on 3rd September.

* * *

The following have recently visited the College :—Mr. and Mrs. B. A. Melhado, British Honduras ; Mr. H. Milburn, Montreal Canada ; Mr. W. H. Jones, Director of Education, Grenada.

* * *

Mr. F. Hardy, Professor of Chemistry and Soil Science, is expected to return from England on 1st October by s.s. *Cavina*. The Colonial Office Scholars will arrive by the same opportunity.

* * *

Mr. G. Evans, Principal, has been appointed Controller of the Cotton Research Station, Trinidad, and of the Empire Cotton Growing Corporation's various interests in the West Indian area.

Mr. R. Silow, of the Welsh Plant Breeding Station, Aberystwyth, has been appointed Assistant Geneticist, Cotton Research Station, Trinidad. Mr. and Mrs. Silow are expected to arrive in November.

* * *

A Conference of Cotton Growers will be held at the College from 31st October to 6th November at which Mr. F. A. Stockdale, Agricultural Adviser to the Secretary of State, is expected to be present.

* * *

Mr. A. Martin Adamson, M.A., B.SC., has been appointed Lecturer in Entomology at the College. Mr. Adamson and his wife are expected to arrive in Trinidad in time for the opening of the coming Session.

* * *

Sir Norman Lamont, BT., Mr. G. Moody-Stuart, C.B.E., and Captain W. F. Watson, O.B.E., have been reappointed for a further period of four years as Trinidad's representatives on the Governing Body of the College.

* * *

Mr. F. J. Pound, Geneticist to the Cacao Research Scheme is expected to return to Trinidad by s.s. *Ariguani* on 16th October. Mr. J. A. McDonald, Chemist to the Cacao Research Scheme is expected to arrive in Trinidad at the end of October.

* * *

Mr. R. C. Wood, Professor of Agriculture, and Miss Wood returned to Trinidad by s.s. *Carare* on 17th September. Mr. A. K. Briant, Assistant to the Commissioner of Agriculture, and Mrs. Briant returned to Trinidad by the same opportunity.

* * *

The College is indebted to the Government of St. Vincent for the gift of a hand cotton gin and an autoclave, and to the Agricultural Superintendent, Dominica, for a gift of a parcel of *Crotalaria oocarpa* seed, a promising new cover crop. Both gifts are greatly appreciated.

Mr. P. E. Turner, Chemist to the Trinidad Sugar-Cane Investigation Committee has been appointed Adviser in Sugar-Cane Experiments to the College Advisory Department of Agriculture. Mr. Turner sailed for St. Kitts and Antigua by s.s. *Lady Nelson* on 11th September, returning on 30th September.

* * *

Mr. A. W. Paterson, of the Gold Coast Department of Agriculture, who has been seconded for special duty at the College and who will be in charge of the office of Professor of Economics during Professor C. Y. Shephard's absence in the Gold Coast, arrived by s.s. *Carare* on 17th September, accompanied by his wife.

* * *

Sir John Evelyn Shuckburgh, K.C.M.G., C.B., has been appointed for a period of four years to represent the Secretary of State for the Colonies on the Governing Body of the College in succession to Mr. E. R. Darnley, who has been co-opted a Member of the Governing Body, also for a period of four years.

* * *

Mr. J. J. C. Buckley of the Staff of the London School of Hygiene and Tropical Medicine sailed for England by s.s. *Presidente Gomez* on 25th July. Mr. Buckley's investigations, while he was at the College were chiefly concerned with the internal parasites of domestic animals, which he studied in particular relation to those of man. Mr. Buckley who joined us in April of last year was a popular figure at the College and will be greatly missed by the many friends whom he made during his stay in Trinidad. Our best wishes go with him in his new sphere of activities.

Marriage.

Congratulations to T. A. Russell (1930-31), Plant Pathologist, Bermuda Department of Agriculture, on his marriage to Miss Patricia Frances Pooley of Cambridge, on 2nd August.

Birth.

Maher. On July 31st, 1933, at Kitale, Kenya Colony, to Margaret, wife of Colin Maher (1928-29)—a daughter.

EXAMINATION RESULTS.

1932-1933.

1st Year:—The following candidates satisfied the examiners in the first year examinations for the Diploma and are eligible to proceed to the 2nd year courses:

R. S. Bancroft.	W. L. Lee.
S. Duncan.	C. C. Seale.
M. S. Hassan.	E. A. Tai.
E. I. Hugh.	A. V. Wan Ping.
H. M. James.	C. G. Wigley.
C. Lai-Fook.	R. D. E. Yearwood.

2nd Year:—The following candidates satisfied the examiners in the second year examination for the Diploma and are eligible to proceed to the 3rd year courses:—

St. G. Cooper.
B. de. B. Darwent.
V. O. Ferrer.
A. Garces.
A. D. Herbert.

3rd Year:—The following candidates satisfied the examiners in the third year examinations and have been awarded the Diploma of the Imperial College of Tropical Agriculture:—

M. Barcant (Trinidad).
J. M. McEwen (Jamaica).
H. C. Miller (Jamaica).
T. E. K. Potter (Trinidad).

SPORTS.

Cricket Club, 1932-33.

MATCH SUMMARY.

Played 8. Won 4. Lost 4.

Versus QUEEN'S ROYAL COLLEGE. Lost.
College: 1st Innings:—62 (Kettlewell 38, Burgess 12)*; 2nd Innings:—64 for 4 wickets (Kettlewell 50*).
Queen's Royal College:—101 for 4 wickets.

Versus QUEEN'S ROYAL COLLEGE. Lost.
College: 73 (Darwent 27, Kettlewell 19).
Queen's Royal College: 107 (Lai-Fook 3 for 17).

Versus Combined Warships. Won.
College: 151 for 8 wickets (Kettlewell 34, Yearwood 55*, Torto 27*).
Combined Warships: 140 (Wigley 3 for 14).

Versus the Staff. Won.
Students: 149 for 3 wickets (Miller 35* Wigley 31, Kerkham 29*, Burgess 28).
Staff: 130 (Wigley 6 for 29).

Versus QUEEN'S PARK CRICKET CLUB. Won.
College: 166 for 6 wickets (Yearwood 44*, Kettlewell 28, Darwent 25).
Queen's Park C.C.: 95 (Wigley 4 for 12).

Versus POINTE-A-PIERRE. Lost.
College: 114 (Burgess 32, Yearwood 19).
Pointe-a-Pierre: 125 (Lai-Fook 5 for 23).

Versus ST. CLAIR CRICKET CLUB. Won.
College: 143 for 5 wickets (Wigley 58*, Burgess 46*, Kettlewell 37).
St. Clair C.C.: 48 (Wigley 3 for 7).

Versus CONSTABULARY. Lost.
College: 1st Innings:—14; 2nd Innings:—26 for 3 wickets.
Constabulary: 170 for 5 wickets.

The Post Graduates also challenged the Diploma Students, the latter winning. Their score was 147 for 4 wickets (Miller 49, Yearwood 36, Darwent 27). The Post Graduates replied with a score of 137 all out (Kerkham 38, Burgess 18). Darwent took 5 wickets for 30 runs.

Cricket Team 1932-33.

Team:—E. D. G. Pritchett, R. W. Kettlewell, B. de B. Darwent, R. K. Kerkham, J. O. Torto, C. G. Wigley, C. Lai-Fook, R. D. E. Yearwood, St. G. Cooper, C. H. Burgess (Captain), B. P. Campbell, H. C. Miller.

* * *

Hockey Club, 1932-33.

The College team had quite a successful season, winning eight matches out of a total of 16 played. Six matches were lost and two were drawn. The two drawn games, *versus* Queen's Park Hockey Club (2-2) and H.M.S. Norfolk (1-1) were probably the best of the season. The four matches played with the Constabulary were all good hard fast games thoroughly enjoyed by both teams.

On its day the team was capable of beating practically any side in the Island, but unfortunately it suffered from bad 'off-days'.

The first round of the Knock-out Competition against the Optimists Hockey Club was won comfortably 6-2; but the College lost the semi-final against the Wanderers Hockey Club 1-3, the team having one of its 'off-days'.

* Not Out.

The following played in most of the matches:—

Forwards: N. M. Wight, E. G. D. Pritchett, A. K. Briant, D. W. Duthie, R. D. E. Yearwood;

Halves: K. Potter, A. V. Coombs, R. W. Kettlewell;

Backs: R. E. D. Baker, C. G. Wigley; Goal: C. C. Webster.

E. Williams, A. Garces, J. McEwen and D. D. Sharma also played for the College.

RESULTS OF MATCHES.

Rover Scouts	Won		1-0
Constabulary	Lost		1-2
Navy	Won		4-1
Leaseholds	Won		11-0
H.M.S. *Norfolk*	Drawn		1-1
Constabulary	Lost		1-3
Rugby Club	Won		8-1
Constabulary	Lost		2-3
Leaseholds	Won		3-2
Queen's Park H.C.	Drawn		2-2
Constabulary	Won		4-0
Rugby Club	Lost		0-3
Rovers H.C.	Lost		1-3
Optimists H.C.	Won	K.O.	6-2
Optimists H.C.	Won		9-0
Wanderers	Lost	K.O.	1-3

Played	16
Won	8
Lost	6
Drawn	2

* * *

Tennis Club, 1932-33.

The College this season entered the newly formed Tennis League Competition for the Diploma Cup. Each match consists of five sets, four doubles and one single, each doubles pair playing twice. The College team was disappointing at first but finished fairly well with wins over the St. Augustine, Queen's Park, Portuguese and Marine Square Clubs, (scoring 28 points for and 32 against). As this competition took place during the Michaelmas and Lent terms, there was little time to arrange other matches.

The following played for the team:—J. A. McDonald, G. G. Gianetti, A. Garces, M. Barcant, C. G. Wigley and R. K. Kerkham.

The College Singles Handicap Tournament began in the Lent term and ended after Easter. In the Semi-finals A. Garces (-15) beat

J. A. McDonald (-30) and R. D. E. Yearwood beat C. G. Wigley. Garces beat Yearwood in the Final. The former is a very much improved player and should do well during the coming season. The Tournament was extremely popular among members of the Club, fifty-four players participating, which must include a very high percentage of the members of the College who have ever held a racquet.

Two matches between Staff and Students were played in the Michaelmas term, and were won by the Staff. The Diploma Students also made some of the Post Graduates wish they had confined their attention to Rugger by beating them 9-0.

The game has been extremely popular throughout the year, while occasions on which one could obtain a free court have been rare.

* * *

Association Football Club, 1932-33.

MATCH RESULTS.

Played	7
Won	4
Lost	2
Drawn	1
Goals for	12
Goals against	8

Opponents.	*Results.*	*For.*	*Against.*
Casuals	Drawn	2	2
Leaseholds	Lost	1	2
Rovers *	Lost	1	3
Constabulary	Won	2	1
s.s. *Cuba*	Won	3	0
H.M.S. *Norfolk*	Won	1	0
s.s. *Carare*	Won	2	0

The Post Graduates defeated the Diploma Students 2-1.

Team :—C. H. Burgess (Goal), H. Miller, E. G. D. Pritchett (Capt.), J. O. Torto, M. Halcrow, R. K. Kerkham, D. F. Stewart, N. M. Wight, K. Potter, J. McEwen, M. Barcant.

Also played :—Goal : R. E. D. Baker ; Halves : C. G. Wigley, R. D. E. Yearwood ; Forwards : A. Garces, J. Cofie, B. de B. Darwent, R. W. Kettlewell, P. de Meillac, A. E. Wyatt, D. G. Whitelaw.

* 1st round of Cup-tie.

OLD STUDENTS' CORNER.

A. Jones (1931-32) has been appointed Assistant Superintendent of Agriculture, Gold Coast.

* * *

A. M. Gwynn (1931-32) has been appointed Entomologist, Nigeria Department of Agriculture.

* * *

C. L. Willding-Jones (1931-32) has been appointed Assistant Superintendent of Agriculture, Gold Coast.

* * *

L. Y. ISRASENA (1931-32) is stationed at the Klong Rangsil Experiment Farm, Tanya Buri, Siam. He has been experimenting with mechanical tillage and has also carried out some seed selection of rice varieties.

* * *

C. A. S. Hynam (1927-31) writes to say that he has been offered the position of Head-teacher in a West Indian School to be established in St. Vincent. It is expected that agriculture will be made a prominent feature in this School.

* * *

J. E. P. Booth (1930-31) is stationed at Bukara, Nyanza Province, near lake Nyanza. This is 20 miles from the Equator, 4,000 feet above sea level. It is the Kavirondo Native Reserve and is in the heart of the new Kakamega gold fields.

* * *

E. W. Leach (1927-28) is making a new station 38 miles from Katsina, Northern Nigeria. He reports that G. N. K. Turnbull (1927-28) is doing locust work, that C. B. Taylor (1927-28) and his wife are very fit and that F. E. Buckley (1927-28) is married.

* * *

R. D. LINTON (1928-29) who is on the staff of the Department of Agriculture, Tanganyika Territory, was, during his first two years, in charge of the Mikuidani Agricultural Station. He is now stationed at Tabora as District Agricultural Officer. His work has been primarily concerned with locusts, groundnuts and cotton.

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